

Beds of medium-to-coarse-grained sand (SP) are typically the most abundant and thickest of all the soil types observed in the soil borings at JPL. In most locations, the average thickness of coarse sand intervals ranges from 15 to 20 feet, although beds thicker than 50 feet or more are common in some borings (see Appendix A). Relatively thick intervals of gravelly sand (SP), sandy gravel (GP), and gravelly sand-sandy gravel (SP-GP) are also common beneath the site though they are slightly less abundant than the coarse sands. Average bedding thickness for these coarse-grained soil types ranges from 5 to 15 feet. Overall, the coarse-grained soil types (SP, GP, and SP-GP) constitute the thickest intervals of soil identified in the borings at JPL.

Fine-grained intervals of silt (ML) and silty sand (SM) are far less abundant in the soil borings than those composed of coarse sand and gravel. Beds of silt (ML) were identified in only a few borings throughout the site where they rarely exceeded 1.0 foot in thickness. Silty sand (SM) beds ranging from 0.5 to 10 feet in thickness are commonly interbedded with the coarser sand and gravel intervals in many locations, though they do not make up a large percentage of the total thicknesses of the soil encountered during the OU-2 investigation.

Clast types found in the sand and gravel intervals of the soil at JPL include fragments of granitic and metamorphic rock types, ranging in size from small cobbles to boulders. These clasts are similar in nature to the crystalline igneous and metamorphic core complex exposed in the southern flank of the San Gabriel Mountains. At a finer scale, many of the sandy and silty soil intervals are micaceous.

The color of the soils at JPL ranges from light orange brown to dark orange brown, brown to dark brown, and reddish brown to dark red brown. Colors are not specific to soil type as different soils may possess the same color. The reddish-brown to dark red-brown colors likely represent soils that were exposed to subaerial conditions for an extended period prior to their burial.

Moisture contents of the soils at JPL tend to vary with grain size. In general, the finer-grained silts and silty sands tend to have the highest moisture. Coarser sand and gravel intervals are typically damp to only slightly moist. Soil densities tend to increase with increasing depth.

Although the vertical and lateral distribution of the interbedded and lenticular individual soil types varies significantly between borings, the overall homogenous, coarse-grained character of the soils at JPL precludes any accurate correlation between locations. Bedding contacts, where apparent, are typically gradational and reflect only subtle variations between soil types. A generalized geological cross section through the north-central portion of JPL is presented in Figure 2-6. For a better understanding of the interbedded and lenticular nature of the subsurface soils beneath the site, refer to the boring logs included in Appendix A.

The only significant change in lithologic character across the site involves clast sizes. Within the sandy gravel and gravelly sand intervals, the number and size of cobbles and boulders tend to increase towards the east, closer to the Arroyo Seco. The lithologic characteristics of the soil in those borings drilled on the north side of the JPL Fault (Nos. 3, 8, 13, and 14) are similar to those soils in the borings on the south side (Nos. 4, 5, 9, 10, and 36).

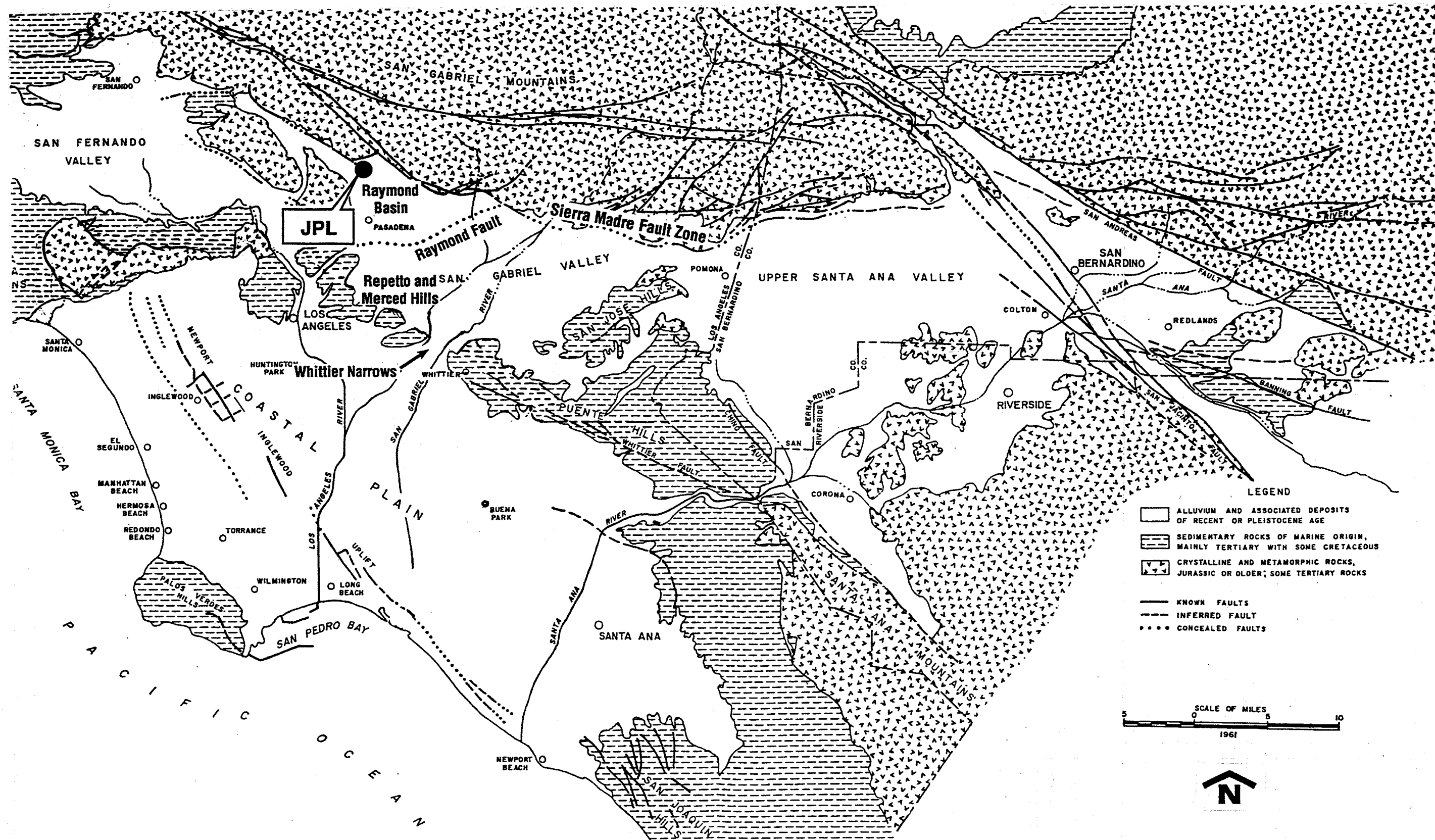
Artificial fill materials were encountered at several locations where drilling and excavation activities were performed at JPL. These fill materials were typically observed immediately below asphalt pavements for roadways and parking lots, extending downward roughly 2 to 10 feet below ground surface. In some locations, it appears that the native soil was screened and re-graded to provide the fill materials. In other locations, the darker brown, greenish-brown, or reddish brown colors of the artificial fill contrasts with the colors of the native soil, indicating that the fill materials were imported.

Small zones of perched groundwater were encountered during the drilling of boring Nos. 20A, 32, and 36. These "perched zones" provide further evidence for the presence of thin layers of fine-grained material within the coarse sand and gravel soils beneath JPL.

2.2.3.3 Water Table Elevations

The aquifer below JPL is generally considered unconfined. However, variations in vertical head measurements in the deep multi-port groundwater wells indicate that the aquifer conditions beneath JPL may not be entirely unconfined. The groundwater table beneath JPL has been regularly measured in 18 on-site groundwater monitoring wells (south of the JPL Thrust Fault) at depths ranging from approximately 30 feet to 270 feet below ground surface. This wide range of depths to groundwater is related to the steep topography present at JPL and to the effects from municipal production wells and the Arroyo Seco Spreading Grounds near JPL.

Groundwater below JPL flows predominantly to the east and southeast across the Raymond Basin, however, the flow direction and gradient can change. During the rainy months, when the Arroyo Seco spreading grounds are used, a groundwater mound, or ridge, beneath the Arroyo Seco can form under the spreading grounds, reversing the local groundwater gradient beneath JPL. At these times, the water flows to the west from the Arroyo Seco as opposed to the east.



Source: California Department Water Resources Bull No. 104. Planned Utilization of the Ground Water Basins of the Coastal Plain of L. A. County, 1961.

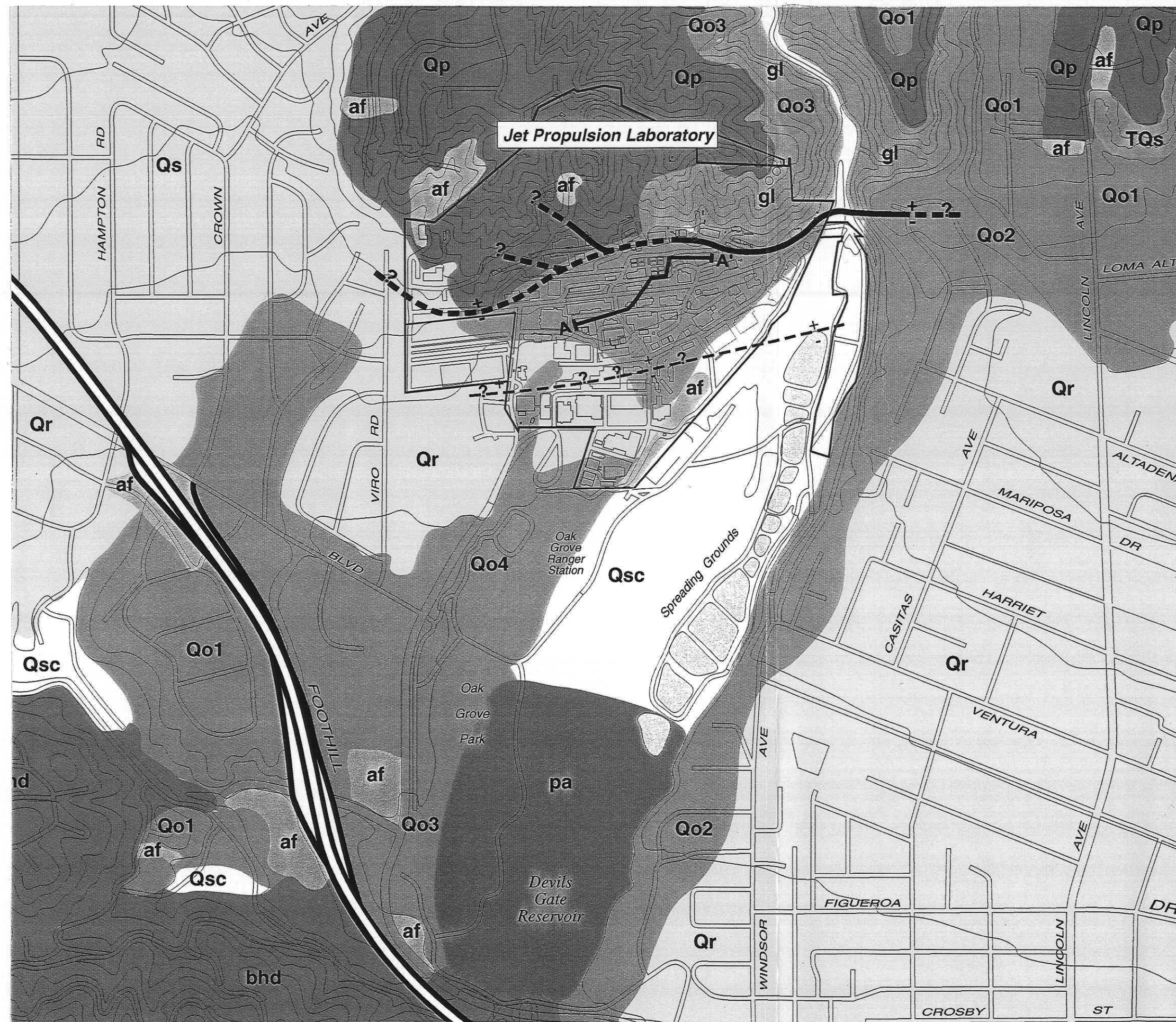
FIGURE 2-1

REGIONAL PHYSIOGRAPHY AND GEOLOGY

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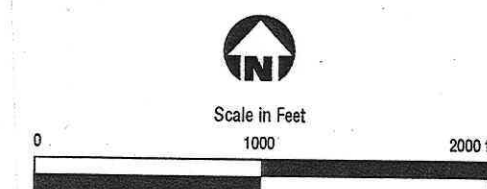
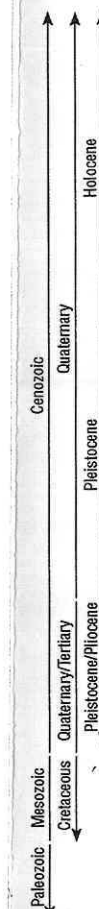


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Explanation

- Lithologic Contact (dashed where approximately located)
- JPL Thrust Fault (dashed where inferred)
- ?? Inferred Fault
- af Artificial Fill
- pa Pondered Alluvium
- Qsc Recent Alluvial deposits
- Qr Stream and channel deposits
- Qr Unconfined alluvial fan deposits
- Qs Slopewash
- Qc Recent Colluvium
- Qo4 Older Fanglomerate Series
- Qo3 Ranges from boulder conglomerate along stream terraces to cobble and pebble sandstone.
- Qo2 Qo4: Deposits on surfaces that have been recently abandoned from further deposition
- Qo1 Qo3: Deposits older than Qo4
- Qo1 Qo2: Deposits equivalent in age to Devils Gate surface
- Qo1 Qo1: Deposits as old or older than the oldest abandoned depositional surfaces of the Altadena Plain
- Local Unconformity**
- Qp Pacoima Formation
- Qp Conglomeratic arkosic sandstone of stream channel and fanglomeratic origin. Commonly weathers to a strong reddish-orange color
- Major Unconformity**
- TQs Saugus Formation
- TQs Arkosic sandstone and conglomeratic arkosic sandstone of stream channel and floodplain origin
- gl Leucocratic Granodiorite
- gl Primarily light gray to buff, fine to medium grained granodiorite
- bhd Biotite-hornblende diorite
- bhd Medium to dark gray, medium grained diorite
- A—A' Location of Cross Section (See Figure 2-6 for Cross Section A-A')



Source: USGS, 7.5 Minute Topographic Map, Pasadena, CA, 1966. Revised 1988, 1994.

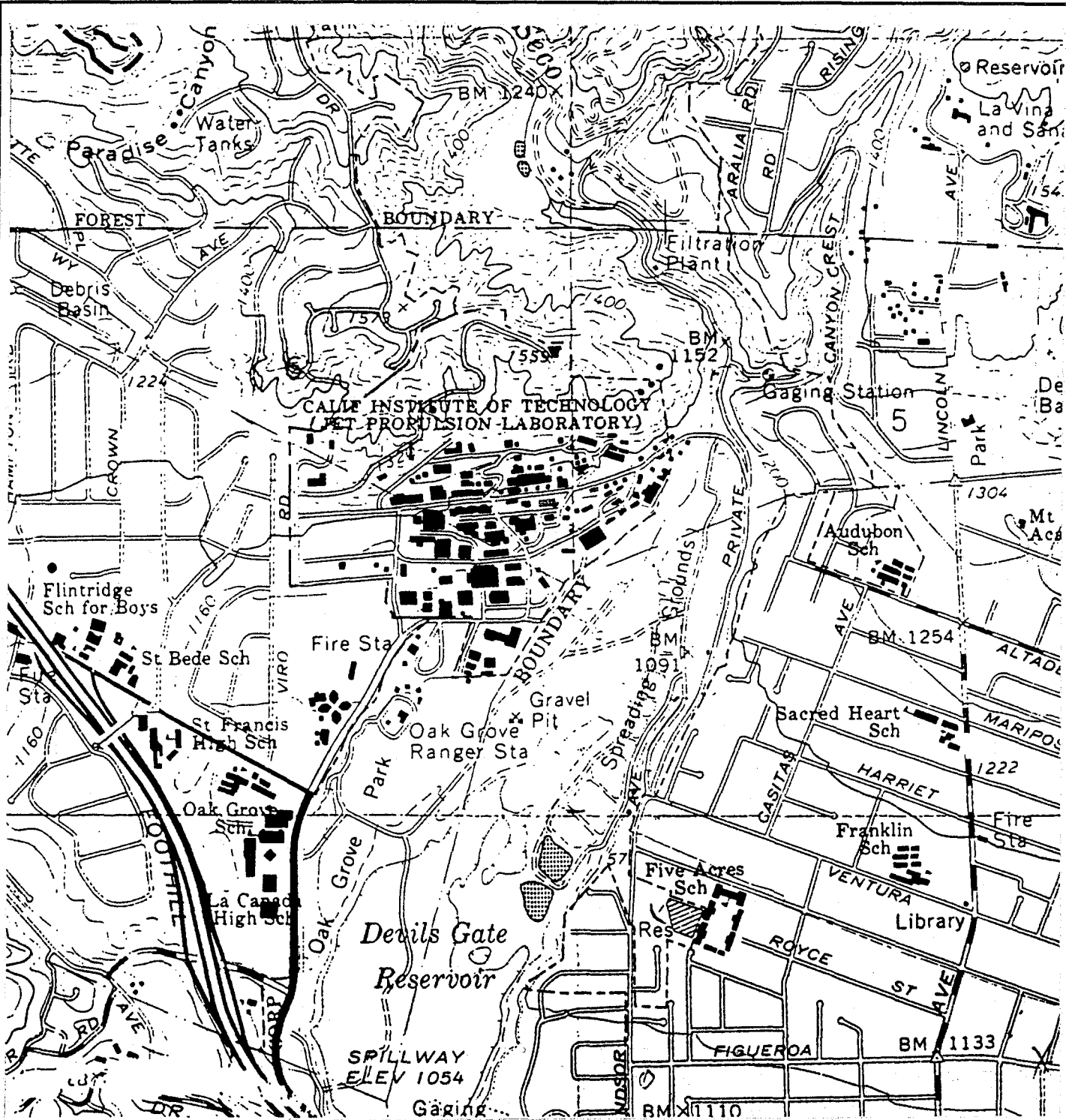
FIGURE 2-2

GEOLOGIC MAP OF STUDY AREA

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Contour Interval: 40 ft.
Scale: 1" = 1300 ft. Approximately

Source: U.S. Geological Survey, Pasadena, California Quadrangle, 1966.

FIGURE 2-3

TOPOGRAPHIC MAP OF JPL AND SURROUNDING AREAS

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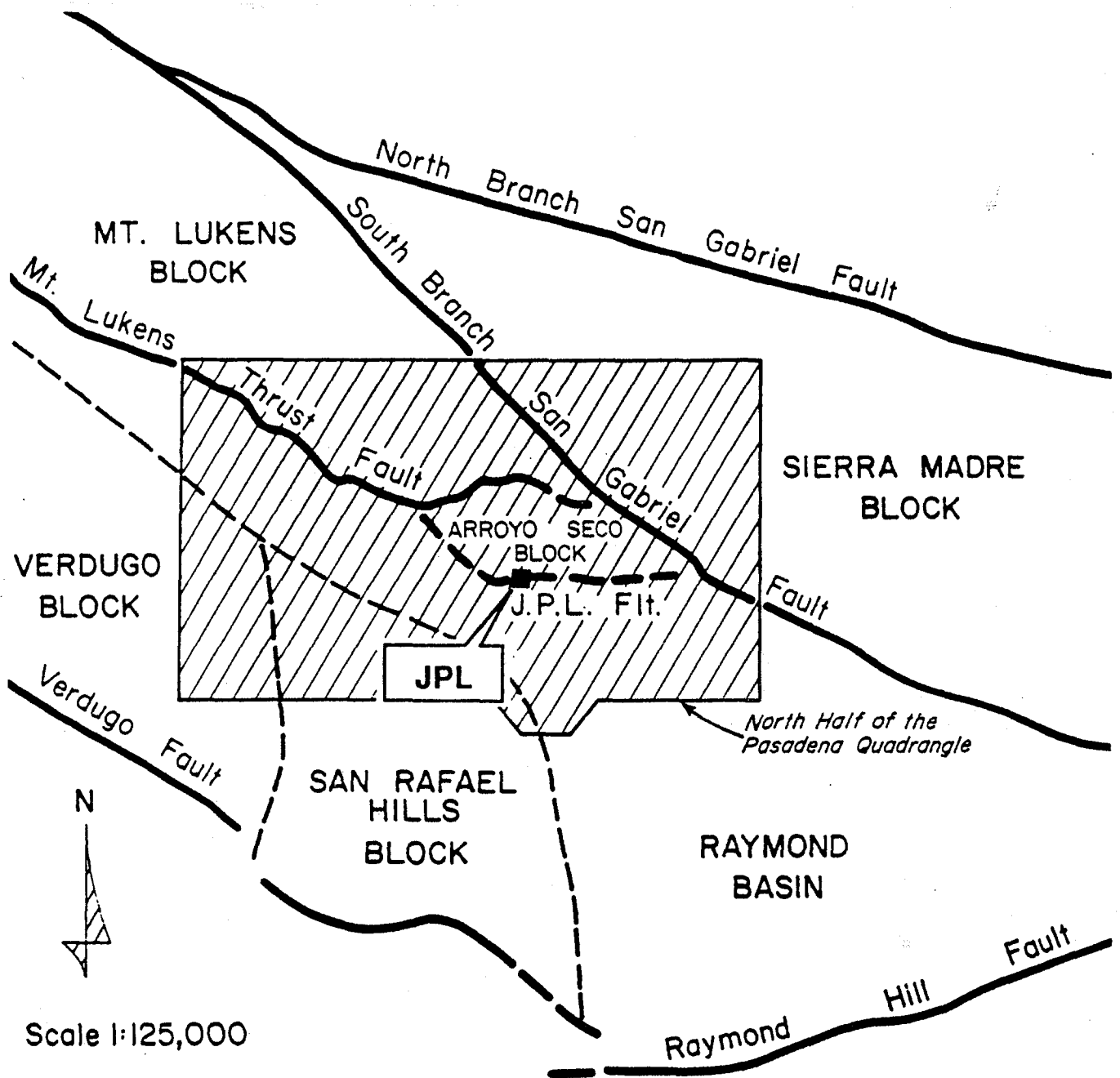


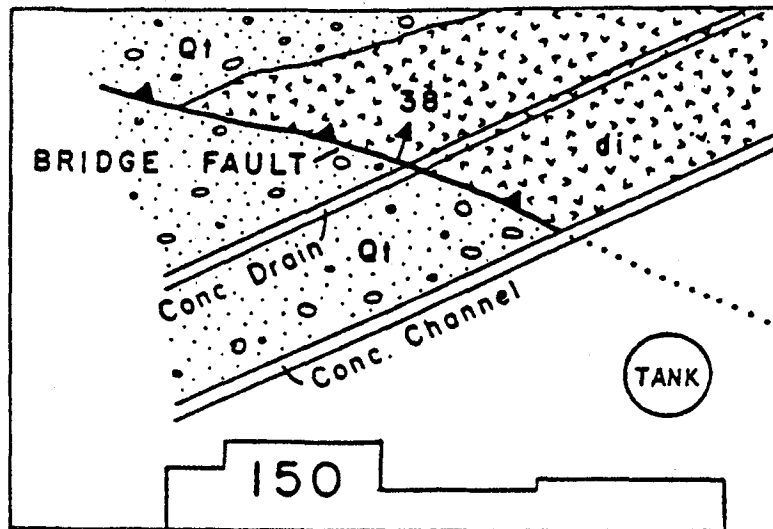
FIGURE 2-4

GENERAL LOCATION OF THE
PRINCIPAL RANGE-FRONT FAULTS NEAR JPL
(Smith, 1986)

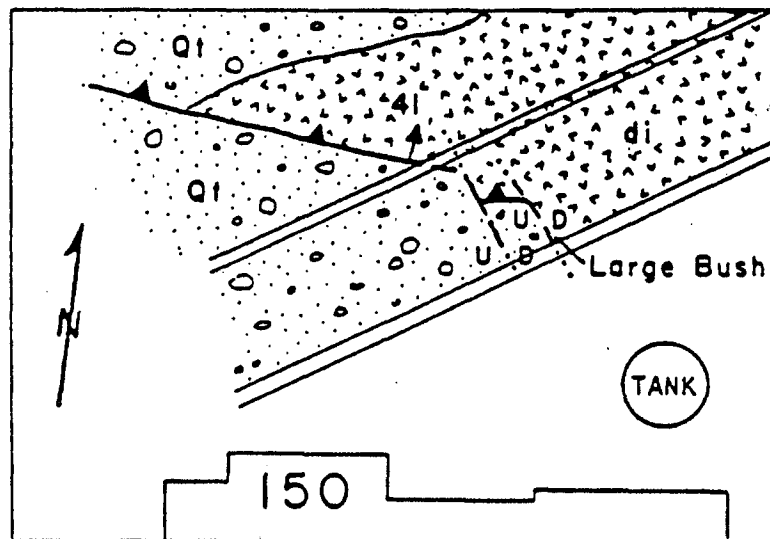
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(a) As mapped by Converse, et al., 1971



(b) As mapped by Agbabian Associates, 1977

0' 50' 100'

- Qt = QUATERNARY TERRACE DEPOSIT
- di = DIORITE
- 38, 41 = DEGREES OF FAULT INCLINATION FROM THE HORIZONTAL
- U = RELATIVELY UPWARD DISPLACEMENT OF FAULT WALL
- D = RELATIVELY DOWNWARD DISPLACEMENT OF FAULT WALL

FIGURE 2-5

JPL FAULT AS MAPPED
BEHIND JPL BUILDING 150
(Agbabian, 1977)

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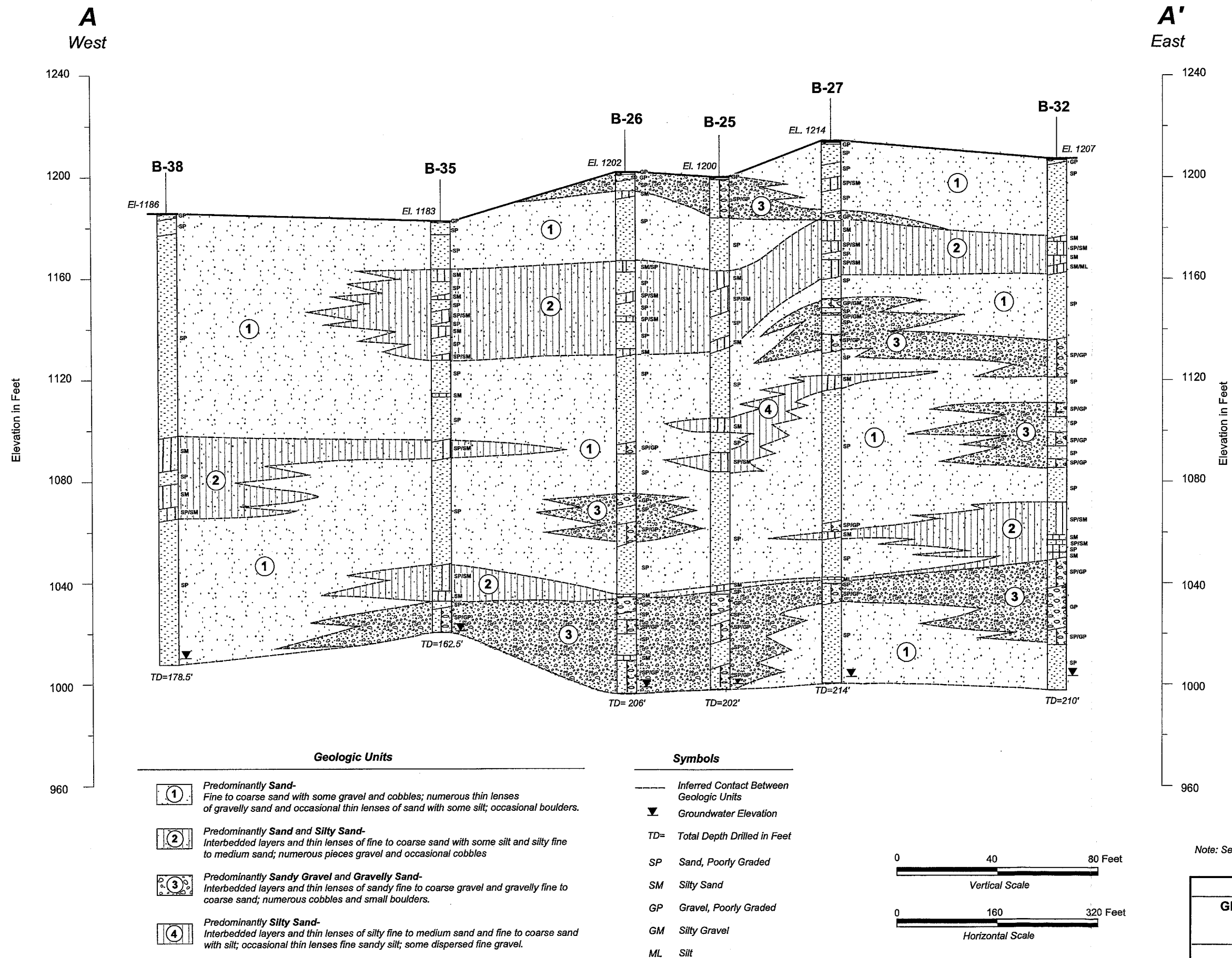


FIGURE 2-6

GENERALIZED CROSS SECTION A-A'
ACROSS THE NORTH-CENTRAL
PORTION OF THE SITE

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3.0 CONTAMINANT SOURCE INVESTIGATION

The OU-2 RI activities were primarily designed to assess the nature and extent of the constituents of concern in the vadose zone (soil and soil vapor) at the JPL facility, to provide data required for a baseline human health risk assessment, and obtain information required to complete the vadose zone Feasibility Study (FS). Major components of this program included the following:

- Conduct a shallow soil-vapor survey at 38 potential contaminant source areas and at 5 non-source locations (monitoring wells MW-12, MW-13, MW-14, MW-15, and MW-16).
- Drill and collect soil samples from 35 soil borings at or as close as possible to contaminant source locations and then convert 28 of those borings into nested soil-vapor wells (Nos. 1 through 24, including Nos. 19A, 20A, and 23B).
- Excavate and collect soil samples from test pits (Nos. 1, 1A, 2, 2A, 3, and 3A) located at or near storm-drain outfalls.
- Drill and install 12 deep soil-vapor wells (Nos. 25 through 28 and 32 through 39).
- Collect and analyze soil and soil-vapor samples to assess the nature and extent to constituents of concern in the vadose zone at the JPL site.

Details of the potential contaminant source areas and field activities associated with the vadose zone investigations are provided in the following subsections.

3.1 POTENTIAL CONTAMINANT SOURCE AREAS

Field explorations for the OU-2 RI were initiated with a shallow soil-vapor survey at 48 locations on the JPL site. This survey was followed by the drilling and sampling of 35 soil borings (including 4 background borings); 28 of these borings were converted to nested soil-vapor wells. In addition, 12 deep soil-vapor wells were later drilled and installed to assess the lateral and vertical extent of VOC vapors in the vadose zone above the groundwater table. Six test pits were excavated with a backhoe to collect near-surface soil samples. A detailed listing of the potential contaminant source locations, types of explorations conducted at each location, and the rationales for collecting soil and soil-vapor samples at these specific locations are presented in Table 3-1 and are summarized in Table 3-2.

Potential contaminant source areas were investigated from 1994 through 1999 during 10 sampling events where either soil or soil-vapor samples were collected to characterize suspected soil contamination in OU-2. The chronology, types of sampling activities, and number of samples collected during each sampling event is summarized in the table on the next page.

Program	Period of Performance	Locations	Sample Media	Number of Samples Collected
Preliminary Soil-Vapor Probe Investigation	1/14/94–1/18/94	SV-1 through SV-58	Soil Vapor	57
Soil Sampling/Vapor Well Installation	8/29/94–10/22/94	Boring Nos. 1 through 24; BG-1, BG-1A, BG-2, and BG-2A	Soil	134
Soil Vapor Well Sampling	12/20/94–12/29/94	Vapor Well Nos. 1-24	Soil Vapor	111
Soil Vapor Well Sampling	3/7/95–3/10/95	Vapor Well Nos. 1-24	Soil Vapor	92
Soil Sampling/Vapor Well Installation	4/1/97–4/14/97	Boring Nos. 25 through 31; Test Pit Nos. 1, 2, and 3	Soil	36
Soil Vapor Well Sampling	6/23/97–6/26/97	Vapor Well Nos. 25-31	Soil Vapor	63
Soil Vapor Well Sampling	7/21/97–7/24/97	Vapor Well Nos. 25-31	Soil Vapor	63
Vapor Well Installation	3/24/98–4/17/98	Boring Nos. 32 through 39	N/A	N/A
Soil Vapor Well Sampling	5/18/98–5/28/98	Vapor Well Nos. 25-28 and 32-39	Soil Vapor	114
Soil Vapor Well Sampling	6/15/98–6/19/98	Vapor Well Nos. 32-39	Soil Vapor	79
Reexcavate and Resample Test Pits	6/10/99	Test Pit Nos. 1A, 2A, and 3A	Soil	6

Soil and soil-vapor samples were collected in an attempt to characterize potential on-site contaminant releases that may have occurred at identified seepage pits/dry wells, waste pits, and discharge points at the JPL facility. The locations of these potential source areas are shown in Figure 3-1. Descriptions of the potential source areas investigated during the OU-2 RI field program are presented in the following subsections.

3.1.1 Seepage Pits/Dry Wells

Seepage Pit Nos. 1 and 2. These two seepage pits were connected in tandem and were used to dispose of liquid wastes from former Buildings 3, 4, 17, and 22 and sanitary wastes from Building 19. Locations of these five buildings, the seepage pits, and associated drain lines are shown on a pre-1949 drawing prepared by the U.S. Army entitled “Master Plumbing Plan for East Portion”, and designated as Drawing No. JPL0901A-0. Names for these buildings however, are not shown on the drawing, and records regarding their use are unavailable.

Construction drawings for Buildings 3, 4, 17, 19, and 22 are not known to exist. However, it is speculated that the seepage pits were not used for sanitary-waste disposal from Buildings 3, 4, 17, and 22 since the drain lines from each of these buildings consisted of 2-inch-diameter cast iron pipe before joining with a 4-inch-diameter vitrified clay pipe. A 4-inch-diameter cast iron pipe extends from Building 19 to the vitrified clay pipe indicating that restrooms were probably inside this building. Details on the construction of the pits are not available.

Since these pits are located in the area having the oldest use-history on the JPL, it is possible that chemicals or solvents may have been disposed in them.

Seepage Pit Nos. 3 and 4. These two seepage pits were constructed in tandem along the north side of existing Building 11 at the locations shown on JPL Drawing No. JPL0901A-0 and used to dispose sanitary wastes from restrooms and a small "kitchen area" (JPL Drawing No. 11/1-0). Drain lines from these rooms consist of 4-inch-diameter cast iron pipe that extend a few feet outside of the building before joining with a 4-inch-diameter vitrified clay pipe leading to the seepage pits.

Building 11 was originally designed to house the administrative and engineering offices for the facility and was maintained to serve in that capacity for a number of years. The building was modified extensively in 1951, and as is indicated on JPL Drawing No. 11/81-0, Seepage Pit Nos. 3 and 4 may have been abandoned at that time. Restrooms were moved to the south side of the building and supposedly connected by cast iron and vitrified clay pipes to other existing seepage pits. The exact locations of these other pits have not been determined as they are not shown to scale, relative to Building 11, nor are their exact locations or dimensions given in any of the available drawings. However, details on JPL Drawing No. 11/81-0 indicate that the pits were constructed with unmortared brick and had a minimum depth of 15 feet.

Prior to 1960, Building 11 was converted to house electrical and plumbing shops and related storage areas for supplies. Solvents were routinely used in repairing, cleaning, and maintaining electrical and plumbing equipment, hardware, tools, and machinery, and spent solvents could have been discharged to the seepage pits prior to being connected to the sewer system.

Seepage Pit No. 5. Seepage Pit No. 5 was located on the south side of former Building 127. It received sanitary wastes from this building as well as similar wastes from former Buildings 68 and 71, according to plumbing details on JPL Drawing Nos. 71/1-0 and JPL0901A-0. Wastes from Buildings 71 and 127 were carried into Seepage Pit No. 5 via a 4-inch-diameter vitrified clay pipe. A 4-inch cast iron pipe tied into that line from Building 127. A 6-inch-diameter vitrified clay pipe was used to convey wastes from Building 68 to the seepage pit. Construction details for this seepage pit are not available; however, it is believed that the pit was located in the lawn area east of existing Building 277.

The historical functions and uses of Building 68 are unknown, as there are no records for this building in the JPL files. Building 71 was originally used for shipping and receiving at the facility and was later converted to "mechanics stores." Building 127 is believed to have been used for vehicle maintenance based on details in JPL Drawing No. 71/1-0 indicating long manway pits for lubricating the underside of vehicles and the location of an Autolite sparkplug cleaner. Solvents and petroleum hydrocarbons used in Building 127 could have been dumped into drains and sinks.

All three buildings are located in close proximity to old solid-propellant bunkers and may have been used intermittently to store chemicals and solvents used in the mixing and development of propellants.

Seepage Pit No. 6. The location of this seepage pit only appears in Drawing No. JPL0901A-0, although no piping is shown to indicate which building it may have served. However, since Seepage Pit No. 6 was located in an area where surrounding seepage pits (Nos. 5, 7, 7A, 7B, 8, 9, and 10) were suspected to be potential sources of chemical or solvent contaminants, it may also be a potential contaminant source.

Seepage Pit Nos. 7, 7A, and 7B. Seepage Pit No. 7 was installed about 15 feet south of the original Building 103, a machine shop in which oils, solvents, and chemical degreasers were used. Additions to the building were built over Seepage Pit No. 7 and necessitated the construction of two additional seepage pits (7A and 7B) farther south. The locations of pits 7A and 7B are shown on JPL Drawing 103/7-0. All three seepage pits were designed to collect sanitary wastes from restrooms.

Building 103 housed a machine shop, metal fabrication shop, and a metal pickling room. Solvents were and are still being used routinely for cleaning and degreasing. It was reported that liquids were dumped into a "drain hole" near the southeast corner of the building. This "drain hole" may well have been one of the clean-out pipes for either Seepage Pit No. 7A or 7B.

Construction details on both of the referenced drawings indicate that the seepage pits were constructed of unmortared brick 5 feet in diameter and were to have minimum depths of 20 feet below finished surface grade. Four-inch-diameter cast iron pipe was used to carry wastes outside of the building's footprint before joining a 6-inch-diameter vitrified clay pipe that discharged into Pit No. 7. Both 4-inch-diameter cast iron and vitrified clay pipe were used to tie Pit No. 7 with Pit Nos. 7A and 7B.

Seepage Pit Nos. 8 (Dry Well), 13, and 13A. These seepage pits were all connected to the interior plumbing of former Building 65. Former Building 65 was used as a materials laboratory that housed two chemistry labs and a chemical-storage area, X-ray and metallurgy lab with a dark room, microscope room, a physics laboratory equipped with a universal testing machine, offices, and a library. Seepage Pit Nos. 8 (dry well), 13, and 13A served former Building 65 in three different ways. Seepage Pit No. 8 was actually a 3-foot-square by 3-foot-deep concrete dry well to collect liquids originating from a pit in the floor where a universal testing machine was located, Seepage Pit No. 13 collected liquid waste from the north side of the building where chemistry laboratory rooms with counter-top and floor sinks were located, and Seepage Pit 13A collected sanitary wastes from the restrooms located on the south side of the building. Locations of the two seepage pits and dry well with respect to Building 65 are shown on JPL Drawing Nos. 65/2-3 and 65/44-0. A fourth seepage pit on the east side of the building was indicated on Drawing JPL0901A-0 but could not be found on the actual construction drawings.

Richard C. Slade (Slade, 1984) investigated Seepage Pit No. 13 using a backhoe to obtain soil samples for analysis (see Section 1.3.3.5) following the buildings' demolition. The only significant finding in Slade's study of this seepage pit was an elevated level of lead with a concentration of 200 mg/kg in an undisturbed soil sample from a depth of 7 feet.

Based on the information presented on the construction drawings, 2-inch-diameter cast iron pipe connected the testing-machine pit to the dry well and was also used to drain the chem-lab sinks to Seepage Pit No. 13.

A combination of 4-inch-diameter cast iron and vitrified clay pipe was used to carry sanitary wastes from the restrooms to Seepage Pit No. 13A. The cast iron pipe extends only 3 feet outside of the building's footprint before connecting with the vitrified clay pipe.

The locations of the two seepage pits and dry well now lie within the footprint of Building 302, the Microdevices Laboratory, which is a two-story structure with a deep basement. To construct the foundations and bottom floor for Building 302, 18 to 21 feet of soil had to be excavated from the building's west side. Since the building site sloped to the east, only about 6 to 8 feet of material were required to be removed from that side of the construction area. There is no documentation in available files on the removal of seepage pits during the excavation operations.

Seepage Pit No. 9. The origin and purpose for Seepage Pit No. 9 is not well documented. It is not known if the pit was originally connected to former Building 44 (the old credit union building), or earlier portions of former Building 13 that housed offices and a small workshop. It is indicated on JPL Drawing No. 13/14-1 that Building 13 was constructed over the seepage pit with the notation "approximate location existing cesspool to be filled after service is discontinued" shown on the drawing. On Drawing No. JPL0901A-0, a cesspool and connection piping is shown to be connected to Building 44, but the seepage pit is located southwest of Building 13. No other records on this seepage pit could be found in available records. However, in either case, the seepage pit locations are well within the footprint of existing Building 302.

Seepage Pit No. 10. This seepage pit was located approximately 15 feet from the northeast corner of Building 78 and is believed to be covered presently by a concrete retaining wall and a bank of horizontally stacked nitrogen gas tanks. The pit's approximate location is shown on JPL Drawing Nos. 78/2-0 and 78/37-0. Drain lines from a lavatory sink and a water closet were connected to the seepage pit via a section of 4-inch-diameter cast iron pipe and an extension of 6-inch-diameter vitrified clay pipe. Lengths of these sections are not shown on the drawings. Construction details for the seepage pit are not available.

Building 78 was first designed and used for housing large hydraulic testing machines. This building is referred to as the "Hydraulics Laboratory" even though the testing machinery was removed a number of years ago. A number of smaller laboratories were housed in this building during its history and included a small laser laboratory, a ceramics room, the "Ocean's Lab," and a cryogenic sensor technology laboratory.

Since solvents are often used to clean up machinery and degrease parts, the likelihood of solvents being used in the hydraulics laboratory is high, and these solvents may have been disposed by pouring them into the lavatory sink.

Seepage Pit No. 11. This seepage pit was used to collect sanitary wastes from former Buildings 101 (Transportation Offices) and 104 (First Aid Building) and was located approximately 40 feet downslope to the southeast as indicated on Drawing JPL0901A-0. Both of these buildings housed restrooms, but interior piping information is not available. Exterior piping, as shown on the referenced drawing, consisted of 4-inch-diameter vitrified clay.

Based on the historical use of these buildings, it is unlikely that interior drains were used to dispose liquid chemicals or solvents.

Seepage Pit No. 12. This seepage pit was located approximately 15 feet northwest of former Chemical Test Cell Building (Building 74) adjacent to existing Building 78's southwest side. Construction details for the seepage pit are shown on JPL Drawing No. 74/23-0.

Building 74 was constructed for testing chemical and liquid propellants, and solvents were used for cleaning and degreasing equipment and hardware. Although only a small sink in this building was connected to the seepage pit via 5 feet of 2-inch-diameter cast iron pipe and 10 feet of 4-inch-diameter vitrified clay pipe, the clean-out for the seepage pit was located just outside of a later-constructed entrance to Building 78 and accessible for dumping chemicals or solvents directly into the pit. It was reported that spent chemicals were poured into the sink on several occasions. Seepage Pit No. 12 was constructed of unmortared brick and had an inside diameter of 4 feet.

Seepage Pit No. 14. Seepage Pit No. 14 was located approximately 20 feet northwest of former Building 46, a workshop building that supported an adjacent liquid propellant test cell (Test Cell "G") housed in Building 42. The location of this seepage pit is shown on JPL Drawing Nos. 42/2-0 and JPL0901A-0.

Solvents were reportedly used to clean the propellant testing devices, hardware, and exhaust areas following the actual tests. The solvents were commonly stored in the shop building. Small spills occurred frequently, and it is possible that spent solvents and other chemicals may have been poured into the shop's counter-top sink.

Sanitary wastes from the restroom were carried through a 4-inch-diameter cast iron pipe to a point at least 3 feet outside the building where this pipe connected to a 6-inch-diameter vitrified clay pipe that drained to the seepage pit. A 2-inch-diameter cast iron pipe connected the sink drain to the 4-inch cast iron pipe outside the building.

Construction details for the seepage pit are not available, but it is assumed that it was of similar construction (unmortared brick) to others located in the area.

The site of former Building 46 now lies within the footprint of existing Building 302, and the seepage pit is believed to be near the sidewalk under the elevated porch leading to the building's main entrance.

Seepage Pit No. 15. According to JPL Drawing No. 33/2-2, Seepage Pit No. 15 was located approximately 38 feet northwest of former shop Building 34 that was demolished prior to constructing Building 300. The old seepage pit location is believed to be adjacent to or under the foundations for Building 300.

This seepage pit collected liquid wastes from a small counter-top sink in Building 34, which served as a work shop area associated with former test-cell Building 33 (Test Cell "F") where various types of liquid propellants were test fired. Solvents and other cleaning agents used in the liquid propellant test cell to clean equipment and hardware may have been stored in Building 34. Small chemical spills reportedly occurred in the test cell over a period of several years, and may also have been disposed by pouring into the sink.

Materials used in constructing the seepage pit are not shown on the drawings, but it is believed that unmortared bricks were used since these materials were found at other nearby seepage pit locations (Seepage Pit Nos. 13 and 16). Dimensions of Seepage Pit No. 15 are also not available. The drain line connecting the sink to the seepage pit was constructed with 4-inch-diameter vitrified clay pipe.

Seepage Pit No. 16. Located approximately 17 to 18 feet southwest of former Building 59, this seepage pit was constructed to receive liquid wastes from a sink inside the building, which originally housed a paint shop and spray booth. Building 59 was later converted to a chemistry laboratory.

During the term that the building served as a paint shop, the potential for disposing paint solvents and thinners into the sink was high. In later years, the sink remained in easy access for the disposal of chemicals.

Seepage Pit No. 16 was investigated by Richard C. Slade using a backhoe for excavating exploration trenches to locate the seepage pit and obtain soil samples for chemical analyses (see Section 1.3.3.5). Slade located the pit, which was constructed of unmortared brick, and obtained undisturbed and bulk samples within the upper 8 feet of soil. Results of the chemical analyses conducted revealed no significant findings.

Construction details of the piping (shown on JPL Drawing 59/1-0) indicate that 2-inch- and 4-inch-diameter cast iron pipes were used to connect the sink to the seepage pit. Also, based on the available information, the seepage pit location is near the northern end of the elevated patio railing along the east side of present Building 303. Building 59 would have been located partly in the area occupied by Building 303's patio and partly in the parking lot on the building's north side.

Seepage Pit No. 17. As shown on Drawing No. JPL0910A-0, this seepage pit was located 60 to 65 feet from former Building 55, which was a solid propellant mixing facility. Construction drawings of the building's interior are not available, but it is assumed that the building housed facilities similar to those in other buildings where solid propellants were prepared. Hence, sinks and tubs for soaking and cleaning the mixing equipment were probably present in Building 55.

Solvents (e.g., carbon tetrachloride, methyl ethyl ketone, trichloroethene, and cyclohexanone) were routinely used to clean the mixing hardware and reportedly disposed, on occasion, by pouring into the sinks and tubs before connections to the sewer system were completed.

A 6-inch-diameter vitrified clay pipe connected the building's drain pipes to the seepage pit. Based on the size of the clay piping, Building 55 probably housed restroom facilities in addition to cleaning sinks.

The area previously occupied by Building 55 is presently a parking area for NASA trucks and buses located near Building 280.

Seepage Pit Nos. 18 and 19. These two seepage pits were connected in tandem to currently existing Building 90 with 4-inch-diameter cast iron pipe and are situated west and southwest of the building (JPL Drawing Nos. 77/25-0 and 90/9-0). Building 90 served as an observation and shop facility for a former solid propellant test cell (Building 51 that was referred to as Test Cell "X") and housed restroom facilities and sinks.

It was reported that test motors and other hardware were cleaned by soaking in tubs of solvents (including acetone and carbon tetrachloride) that were not recycled and allegedly dumped into sumps (Seepage Pit Nos. 18 and 19) on the west side of Building 90 or at the east end of the solid propellant preparation area.

Details on the seepage pits are not available, but they are assumed to be constructed with unmortared bricks since these materials were used in seepage pits at other buildings constructed during the same time frame.

Seepage Pit Nos. 20 and 21. Former Buildings 58 and 63 were joined together and, in combination, housed large compressors, maintenance shops for the compressors and other machinery. By 1960, the combined structure was referred to as Compressor Building 58. Seepage Pit No. 20 was connected to the original Building 63 by approximately 40 feet of 4-inch-diameter cast iron pipe with a 60-foot extension of 6-inch-diameter vitrified clay pipe. The locations of Seepage Pit 20 and the pipeline are shown on Drawing JPL0902A-1. Following the merger of designations for Buildings 58 and 63, a second seepage pit (Seepage Pit No. 21) was constructed about 16 feet east-southeast of Pit No. 20 (JPL Drawing No. 77/25-0). Information on the type and size of the pipe connecting the two seepage pits is unavailable.

Neither construction drawings nor interior plans for Building 63 are in the available files, so the interior draining system (including restrooms, sinks, floor drains) is not known.

Solvents were routinely used to clean parts and machinery, and were commonly stored where they are used. Spent solvents could have easily been poured into sinks or floor drains (if present).

Former Building 58 has been demolished and the two seepage pit locations are covered by a filled and graded parking lot. In addition, the location of Seepage Pit No. 21 may underlie the

foundation for the retaining wall on the south edge of the parking lot adjacent to the north side of Aero Road.

Seepage Pit No. 22. The location of Seepage Pit No. 22, as shown on JPL Drawing No. 77/25-0, is near former Building 80 that housed a wind tunnel. Construction details for the seepage pit, piping, and Building 80 are not in JPL's files.

Based on information available, there were no reports of solvents or chemicals being used in this building.

The area formerly occupied by Building 80 is presently an asphalt-paved parking lot north of existing Building 79, and the parking lot is covered by office trailers. The seepage pit location is beneath the office trailers.

Seepage Pit Nos. 23, 24, and 25. Locations of these three seepage pits are shown on Drawing No. JPL0902A-0. They served existing Building 67 by collecting liquid and sanitary wastes from a diverse number of small laboratories and four restrooms. Although primarily an office building, small laboratories and research rooms (e.g., biology, kinetics, low-level radioactive, magnetism, computer development, range correction, spectroscopy, etc.), as well as storage rooms for finished components and parts, were housed in Building 67 during its history of occupancy. Several of these laboratory rooms existed prior to connecting with the sewer system.

There are no records for the types and amounts of chemicals used in this building and their usage was unknown to interviewees. Also, construction details for the seepage pits are not available. As indicated on Drawing JPL0902A-0, 6-inch-diameter vitrified clay pipe was used to convey the liquid and sanitary wastes to the seepage pits from the interior 4-inch-diameter cast iron plumbing lines. Seepage Pit Nos. 23 and 24 are beneath the asphalt-paved parking area along Explorer Road south of the building's central section, and Seepage Pit No. 25 is beneath a walkway or landscaping near the west end of the building on its south side.

Seepage Pit Nos. 26 and 28. Seepage Pit No. 28 has been referred to as a "dilution tank" (JPL Drawing No. 77/1-0), an "acid sump" (JPL Drawing No. 77/2-0), a "fluorine pit" (JPL Drawing No. 77/4-1), and a "cesspool" (JPL Drawing No. 77/21-1). In actuality, the pit was originally designed and constructed to receive exhaust gases from a fluorine propellant test cell located in former Building 77. A 23-foot-long steel pipe having an inside diameter of 18 inches sloped downward from the test cell, at an angle of 30 degrees, to the pit that was situated on the building's north side. Notations on JPL Drawing No. 77/2-0 called for the pit shaft to be constructed 4-foot square with "walls to be of suitable material" to a depth of 15 feet, plus or minus, with a 2-foot-thickness of crushed limestone at the bottom. It is indicated on JPL Drawing No. 77/1-0 that the shaft was 5 feet in diameter and 20 feet deep. Floor drains located in two of the building's rooms were connected to the shaft by 2-inch- and 4-inch-diameter cast iron pipes.

Building 77 also housed an experimental chemistry laboratory and various chemicals may have been dumped into the exhaust shaft (Seepage Pit No. 28). Crushed limestone was placed at the bottom of the shaft to neutralize fluoric acid produced during experimentations with fluorine propellants. Interviewees reported that numerous chemicals were disposed by dumping into available "sumps" near the building.

Seepage Pit No. 26 was located on the south side of Building 77 and received both liquid and sanitary wastes from, respectively, sinks and a restroom. Exterior piping consisted of 4-inch-diameter vitrified clay (JPL Drawing No. 77/33-0). Construction details for this seepage pit and the building's interior plumbing are not available.

Most of the area formerly occupied by Building 77, including Seepage Pit No. 28, is now covered by existing Building 299. However, the location of Seepage Pit No. 26 is believed to be in Pioneer Road near the west end of Building 299 (JPL Drawing No. 299C010A0-0). It should be noted that both of these seepage pits are located upgradient from monitoring well MW-7.

Seepage Pit No. 27 (Dry Well). This seepage pit is a dry well constructed of precast reinforced concrete pipe sections topped with a standard concentric cone section of similar materials. The pit receives liquid wastewater through a 2-inch-diameter cast iron pipe from two small counter-top sinks located in Soils Laboratory Building 246. These construction details, as well as the dry well's location, are shown on JPL Drawing No. 246/3-10.

Primary activities at Building 246 involved experimentation with soil conditioning and various types of vegetation to evaluate the most effective methods for revegetating slopes and controlling erosion. There is no history or knowledge of solvents or petroleum products having been used at this location.

Seepage Pit No. 29. According to JPL Drawing No. 32/1-0, Seepage Pit No. 29 was located between former Buildings 32 and 20 in the liquid propellant testing area. Building 32 housed the test cell where solid propellants were fired during the late 1940s and liquid propellants during the mid-1950s. Building 20 was the shop used to provide support for the test cell in Building 32.

The seepage pit was designed for collecting liquids from two floor drains located in the test cell. Each drain was located near the center of sloped gutters along opposing walls in the test cell's firing bay. The drains were connected to the seepage pit by 4-inch-diameter vitrified clay pipe. It is noted on the referenced construction drawing that the seepage pit was to have a 4-foot inside diameter and extend to a depth of 16 feet with no overflow. Construction materials were not specified. Unmortared bricks were probably used to construct the pit's shell since some red bricks were excavated from that location when Buildings 20 and 32 were demolished and the area regraded for constructing a parking lot.

Solvents were commonly used to clean the propellant testing motors and associated hardware. It has been reported that solvents, degreasers, and chemical cleaners were applied with rags, paint

brushes, or spray bottles and then wiped-down by hand or hosed-off with water. Solvents commonly used during JPL's early years included carbon tetrachloride, methyl ethyl ketone, and acetone.

Seepage Pit No. 30. Existing Building 117 formerly housed a solid propellant test cell and a seepage pit was located approximately 7 to 8 feet from the south wall near the southwest corner of the building (JPL Drawing Nos. 117/50-0 and 117/50-4). A small counter-top sink was located inside the building opposite the seepage pit location. Restrooms were not housed in the building. Construction details are not available for either the seepage pit or the piping connections.

Solvents were commonly used to clean rocket motors and hardware, and these solvents reportedly were not recycled, but were disposed of by dumping into nearby sumps and drains.

Seepage Pit No. 31. As shown in location and grading plan details on JPL Drawing No. 107/69-0, Seepage Pit No. 31 is located about 9 feet due south of Building 112's (now Building 107) southwest corner almost directly between Building 112 and former Building 12. Piping diagrams are not shown on this drawing and there is a possibility that the seepage pit was connected to both buildings. Restroom facilities were not located in Building 112 and records for Building 12 are not available.

At one time, Building 112 housed two liquid propellant test cells. In the early 1960s, this building merged with Building 107 (also a test cell for liquid propellants), and the combined structure is presently referred to as Building 107. This combined structure later housed plasma flow and laser research laboratories, and it is currently associated with laser and robotics development.

Solvents were used routinely in the liquid propellant test cells for cleaning and degreasing experimental firing equipment and hardware. Spills commonly occurred, but were reportedly small.

The purpose for Seepage Pit No. 31 is not clear, and construction details (other than location) regarding its size, depth, and composition are not available.

Seepage Pit No. 32. This seepage pit is located on the south side of existing Building 86 and apparently collected liquid wastes from existing Buildings 98, 87, and, possibly, 88. The pit's location is shown on JPL Drawing No. 98/1-0, which includes piping details on drains coming from Building 98 (containing 5 floor drains), and lead-in drains originating at Buildings 86 and 87. Exterior piping is indicated as both 4-inch-diameter vitrified clay and cast iron, while interior piping consists of 2-inch-, 3-inch-, and 4-inch-diameter cast iron.

A plumbing diagram on JPL Drawing No. 88/1-0 shows a 4-inch-diameter vitrified clay pipe leading away from the building. The drawing detail notes "4 (in.) VC to dry well, see plot plan." However, the plot plan could not be found in JPL's records. This line could run to Seepage Pit No. 32, or it could lead to another unidentified pit west of Building 86. In fact, the plumbing

diagram on JPL Drawing No. 86/7-3 does not show a seepage pit at the location indicated on Drawing 98/1-0, but does show an exterior 3-inch-diameter cast iron pipe leading westward from the inferred seepage pit location at Building 86 with the notation "3 (in.) CI soil pipe to cesspool, see plot plan."

Buildings 86, 87, 88, and 98 are all located at the east end of the solid propellant preparation area where numerous types of solvents were used to clean mixing equipment and hardware.

No other construction details on Seepage Pit 32 are available.

Seepage Pit No. 33. According to the plumbing details shown on JPL Drawing No. 97/1-0, Seepage Pit No. 33 is located 16 feet from the west end of existing Building 97 and collected liquid wastes from 4 counter-top sinks, two floor drains, and a series of unidentified wall-mounted inlets. Two- and 4-inch-diameter cast iron pipe was used inside the building and connected to an exterior 4-inch-diameter vitrified clay pipe leading to the seepage pit.

Restroom facilities, located on the north side of Building 97 near its east end, are shown on Drawing No. 97/1-0 to be connected to an unidentified pipe exiting the building, but no indication is given as to its destination. No other information is available on piping, connections, or construction of the seepage pit.

Building 97 was a development laboratory for solid propellant chemistry experimentation and numerous solvents were used to clean laboratory hardware, including acetone, carbon tetrachloride, methyl ethyl ketone, and trichloroethene. During the employee interviews, it was reported that sumps in the vicinity of Building 97 were used to dispose spent solvents.

Seepage Pit No. 34. On JPL Drawing No. 98/2-1, Seepage Pit No. 34 is noted as a 20-feet-deep dry well located about 9 feet north of the east end of existing Building 98. A floor drain in a small exterior storage area was connected to the dry well by 4-inch-diameter cast iron pipe. This building was originally designated as "Cleaning and Spray Building" and housed a larger "cleaner room" with a floor that sloped to a drain in the center of the floor. A 4-inch-diameter interior cast iron pipe and 4-inch-diameter vitrified clay pipe connected this drain to Seepage Pit No. 32 located on the south side of Building 86 as shown on JPL Drawing Nos. 98/1-0 and 98/7-0. A roofed solvent-storage area underlain by a concrete slab is shown on the drawing to be adjacent to the dry well.

Building 98 was later (early to mid 1950s) converted to a solid propellant preparation shop. Solvents were used to clean mixtures of propellant chemicals and binders from mixing equipment and related hardware. Reportedly, a pit at the east end of the solid propellant preparation area in the vicinity of Building 98 was used for disposal of carbon tetrachloride, methyl ethyl ketone, trichloroethene, cyclohexanone (maybe), and other chemicals after the sewer system was installed.

Seepage Pit No. 35. This seepage pit received liquid and sanitary wastes from former Building 81 that housed offices, workshops, storage rooms, and restrooms. The seepage pit was located approximately 35 feet in a southeasterly direction from the building's western end according to plot-plan details on JPL Drawing Nos. 81/3-2 and 81/43-0. Sanitary wastes were conveyed from the east end of the building through a 4-inch-diameter vitrified clay pipe that joined with a 6-inch-diameter vitrified clay pipe from the building's west end just before connecting with the seepage pit.

Construction details for the seepage pit are not available, but it is assumed that it would be similar to others nearby that are constructed with unmortared brick. Also, it is indicated on the referenced drawings that this seepage pit was also connected to Seepage Pit Nos. 1 and 2.

Seepage Pit No. 36. This seepage pit was discovered during the removal of a large, storm drain catch basin that was constructed directly over the top of the pit. Its location is not shown on any plans or drawings in available files, so it cannot be determined which building was connected to Seepage Pit No. 36. However, because it was located approximately 20 to 25 feet in front of Building 107, it may have been connected to this building at one time. Construction workers reported that the pit was 4 to 5 feet in diameter and constructed with unmortared red bricks.

Soil sludge in the demolished catch basin was reported to contain elevated concentrations of carbon tetrachloride, acetone, trichloroethene, methyl ethyl ketone, tetrachloroethene, styrene, and mercury. Detailed information is presented in Section 1.3.3.9.

Seepage Pit No. 37 (Dry Well). As noted on Drawing No. JPL0901A-0, this seepage pit was described as a dry well and was connected to Building 2 that housed an inspection and gage laboratory. The purpose for the dry well, as well as details on its construction piping, and size are not available.

The final number of seepage pits identified during this effort was 40 since Seepage Pit Nos. 7A, 7B, and 13A are included in the total count. Locations of all the seepage pits/dry wells described above are shown in Figure 3-1.

3.1.2 Waste Pits

Waste Pit No. 1. This waste pit (WP-1) was not an actual pit as such, but was an open area where wastes may have been conveniently disposed. This area could have been a channel or gully caused by erosion at the location where a 36-inch-diameter storm drain empties into the Arroyo Seco near the south end of Building 103. It has been allegedly reported that small amounts of spent solvents, mercury, and other wastes were intermittently dumped in this area.

Waste Pit No. 2. During the late 1940s and early 1950s, a large shallow depression (WP-2) was bulldozed in the Arroyo Seco at the location shown in Figure 3-1. This depression was reportedly used primarily for the disposal of glass and metal shavings, and can be seen in aerial photograph Nos. JB931C and JB931H presented as Figures 1-17 and 1-19 in Section 1.

Waste Pit No. 3. A former salvage storage area located just southeast of existing Building 248 was reportedly used for the disposal of solvents. This area is shown in Figure 3-1 and is designated as WP-3. It was reported that approximately three 55-gallon drums of diluted solvents were allegedly dumped into two or three hand-dug holes every 3 to 4 months over a period of 2 to 3 years during the late 1950s. The holes were approximately 25 feet apart, about 4 feet wide by 3 feet deep, and were located east of former Building 119 that was identified in aerial photograph No. JB1673B from the JPL Photo Library (see Figure 1-20, Section 1).

Waste Pit Nos. 4 and 5. Two trenches identified by the EPA (EPA, 1993, Figure 7) on an aerial photograph dated November 17, 1952, were designated as Annotations H and I (WP-4 and WP-5, respectively) during their aerial photograph analysis (see Section 1.3.3.14). It was suggested by the EPA that these two trenches, located in the southeast portion of the site adjacent to the Arroyo Seco, may represent waste-disposal activities.

Both trenches were outside of the JPL boundary at the time the aerial photograph was taken and neither trench was part of JPL's operations. Therefore, historical information on their use or contents is not available. Based on the photograph and the locations of significant monuments, it is believed that all of WP-5 (Site I) and part of WP-4 (Site H) are covered by the parking lot along the southeast boundary of the JPL facility. Locations of all the waste pits previously described are shown in Figure 3-1.

3.1.3 Discharge Points

Discharge Point 1. Discharges to the Arroyo at three locations were reported in a City of Pasadena Water Department field inspection report dated August 26, 1948. The first discharge point (DP-1) was reported to be from a large corrugated iron pipe located south of Building 103 (in the vicinity of the existing storm-drain outfall) and consisted of a yellow oily substance that was fairly clear and free of objectionable odor.

Discharge Point 2. The second discharge point (DP-2) was located where a main north-south drainage through JPL entered the Arroyo near the southern extremities of the facility. This would have occurred near where the southern tip of the Southern California Edison substation is located today. Although no discharge was observed at the time the field inspection was made, there was evidence of previous discharge in the form of a channel blackened with a deposit of dark, odorless, pigment-like material. It was reported that considerable flow occurred at this location when combustion chambers were washed down.

Discharge Point 3. In memo notes, dated February 27, 1961, by the City of Pasadena Water Department, it was recorded that yellow-colored discharges into the Arroyo Seco from a JPL storm drain had occurred. The discharges originated as bleedoff, containing sodium chromate, from Cooling Tower No. 118 and emptied into the Arroyo from the storm-drain outfall located where the 48-inch-diameter outfall is presently situated south of the Southern California Edison substation.

Discharge Point 4. The fourth discharge point (DP-4) was reported to be from a 12-inch drain that originates north of Building 103, passes under Building 103, and discharges at the Arroyo bank. It was reported that the discharge consisted of a black, coal-tar-like substance with a strong objectionable odor that resembled petroleum derivatives. The discharge was in a small sump area and not of sufficient quantity to reach the streambed proper.

Locations of the four discharge points mentioned above are shown in Figure 3-1.

3.2 PRELIMINARY SOIL-VAPOR INVESTIGATION

Discussions on the installation of soil-vapor probes and the collection of soil-vapor samples during seven sampling events are presented in the following subsections.

3.2.1 Soil-Vapor Survey (Event 1)

Forty-eight (48) soil vapor sampling probes were installed at the locations shown in Figure 3-2. Each soil-vapor sampling probe was installed using either a truck-mounted, hydraulic-ram driving/hammering system or a portable, manual impact-hammer system. The hydraulic-ram system was used where a mobile sampling truck could gain access to the sampling location. The truck-mounted system used two hydraulic rams mounted vertically at the back of the vehicle to push, or drive, the probe into the ground. The sampling probe, connected to the bottom of a section of 1.5-inch-diameter, 4-foot-long, hollow drive rod, was driven vertically into the ground using the hydraulic rams. Additional sections of drive rod were added until the sampling depth was reached or refusal occurred.

A portable, manual impact-hammer system, utilizing 1.0-inch-diameter, 4-foot-long hollow drive rods, was used in areas inaccessible to the sampling truck. An electric-powered impact-hammer was attached to the top section of the drive rod, and a sampling probe was connected to the bottom of the drive rod. The probe was then driven into the ground using the impact hammer. Additional sections of drive rod were added until the sampling depth or refusal was reached.

Soil vapor sampling probes consisted of a cone-shaped, hardened drop-off steel tip attached to sterile 1/8-inch-outside diameter (OD) nylon tubing (Nylaflow®) that extended from the probe tip to the ground surface through the hollow-steel drive pipe. When the sampling depth was reached, the hollow-steel drive rod was raised slightly to expose the inlet holes in the steel tip. Soil vapor was then able to enter the system through inlet holes when a vacuum was applied to the top end of the nylon tubing (Figure 3-3). Following sample collection, the drive rod was removed leaving the sampling probe in place.

To minimize the possibility of atmospheric interference and sample dilution, soil-vapor samples were collected at depths not less than 5 feet below grade. Once the sampling depth was reached and the soil-vapor sampling tip was in place, the annular space between the soil vapor sampling tube and the surrounding soil formation was backfilled using the following procedures:

- No. 3 silica sand was poured into the annular space adjacent to and approximately 6 inches above the perforated section of the sampling tip.
- Fine bentonite granules were placed from the top of the sand to approximately 6 inches below the ground surface and hydrated with distilled or deionized water. The water was added while the bentonite was being placed to ensure hydration of the entire bentonite column.
- The top of the Nylaflo® tubing extended approximately 1 foot above grade and was capped with an air-tight, 1/8-inch Swagelok® tubing cap.
- The probe sampling tip effectively seals off the annulus of the drive rods during the insertion of the tip into the soil, so the annulus remains clean and free from contact with any potential contaminated soil particles. All drive rod exteriors were washed with a mild solution of Alconox® (a phosphate-free detergent) and then a double rinse with deionized water before they were reused. An ample supply of drive rods were provided so that no waiting time was required for decontamination between probe installations.

Depths of the soil-vapor probes are listed in Table 3-3.

3.2.2 Soil-Vapor Sampling and Analysis (Event 1)

Soil-vapor samples were withdrawn from the soil through the sampling tips and Nylaflo® tubing using a calibrated, gas-tight, 20-cubic-centimeter (cc) sterile syringe fitted with a three-way on-off valve. Prior to collecting the soil-vapor sample, four volumes of the length of the tubing were purged to flush the tubing and fill it with in-situ soil vapor. Since each foot of tubing has an internal volume of 1 cc, the total volume purged was easily measured with the calibrated syringe. Following purging, a 20-cc soil-vapor sample was collected in the syringe, the valve turned to the off position, and transferred immediately to the on-site mobile laboratory for analysis. Neither water vapor nor condensation was observed in the transparent sampling syringes during this sampling event. A typical schematic for the soil vapor survey sampling system is presented in Figure 3-4. Because the purge and sample volumes were small, a vacuum pump was not required to evacuate the tubing or to collect a soil-vapor sample. To demonstrate reproducibility of results, a duplicate soil-vapor sample was collected and analyzed after every five samples.

Samples collected during the soil-vapor survey were analyzed on-site in a mobile laboratory certified (Certification No. 1667) by the California Department of Health Services (CDHS) to perform analyses by EPA Methods 8010 and 8020 for the parameters listed in Table 3-4.

3.3 DRILLING AND SOIL SAMPLING PROGRAMS

The primary objectives of the drilling program were to obtain information on subsurface lithology, to collect relatively undisturbed soil samples for visual examination and laboratory analysis, and to install soil-vapor wells. For all three drilling methods (percussion hammer, sonic, and hollow stem auger) used during the OU-2 RI, lithologic descriptions of the soil were

recorded on field boring log forms based on the Unified Soil Classification System (USCS) (Figure 3-5), and included the following:

- Physical characterization and grain-size distribution,
- Color changes,
- Presence of moisture,
- Stratigraphic boundaries,
- Thickness of individual units
- Locations of samples taken and percentage of sample recovery,
- Presence of any inferred visible contamination,
- FID measurements and noticeable odors, and
- Any other conditions encountered during drilling (e.g., perched groundwater, difficulties, etc.)

Logs for all borings drilled during the OU-2 RI are presented in Appendix A. Discussions on drilling methods and the various methods to collect soil samples during the OU-2 RI field programs are presented in Sections 3.3.1 and 3.3.2, respectively. Descriptions of how the soil-vapor wells were installed are contained in Section 3.4.

3.3.1 Drilling Methods

Percussion hammer, sonic, and hollow stem auger drilling methods were used to drill soil borings and soil-vapor wells during the OU-2 drilling program.

3.3.1.1 Percussion Hammer

Soil boring Nos. 1 through 24 were drilled with a percussion hammer drilling rig that utilized dual-wall drive pipe and reverse-air circulation. The dual-wall percussion method of drilling consisted of driving a double-walled pipe with a diesel-operated drive hammer while filtered air is forced downward through the annulus of the dual-wall drive pipe to the drill bit. The air returns upward through the inside of the drive pipe, bringing with it a continuous stream of drill cuttings. A water-mist injection was occasionally used to assist the drilling, recover the drill cuttings, and dust control.

The drive pipe consisted of two heavy wall pipes joined together (one suspended inside the other). A neoprene O-ring was used at each joint to prevent the air from escaping between the two pipes. A petroleum-hydrocarbon-free dope was used as the tool-joint lubricant. The external flush jointed drive pipe was not rotated, but rather driven into the ground with the drive hammer which delivered over 8,000 foot pounds of energy per blow at more than 90 blows per minute. This method was able to penetrate sand, silt, clay, gravel, fractured rock, and cobble formations, but was often unable to penetrate very hard massive boulders. Withdrawal of the dual-wall pipe

was accomplished by a pulling system consisting of two 50-ton-capacity hydraulic cylinders operating a tapered slip arrangement that grips the outside of the double-wall drive pipe. Handling of the drive pipe was accomplished by means of a hydraulically operated cable lift arrangement.

The outside diameter of the dual-wall drive pipe used was 9 5/8 inches and the inside diameter of the inner pipe was 6 1/2 inches. Each pipe section was 10 feet long. The outside diameter of the drill bit ranged from about 0.5 to 1.0 inch larger than the drive pipe. All internal and external surfaces of the drill bits and sections of drive pipe were steam cleaned before being used in each soil boring. Drill cuttings circulated by air out of the boring went through a cyclone device before being collected in portable 2-cubic-yard bins. Soil cuttings and the discharged air were routinely screened with an organic vapor analyzer (OVA) for organic vapors as required for health and safety purposes as described in the Health and Safety Plan (HASP) (Ebasco, 1993f).

Upon completion of drilling and sampling of each boring not converted to soil vapor monitoring wells, the borehole was backfilled to the ground surface with bentonite granules (Benseal®) that were hydrated with potable water as they were placed. The dual-wall drive pipe was used as a tremie during backfilling operations and was removed, one section at a time, while the bentonite granules were added. Holes in asphalt or concrete pavements were repaired with like materials. Backfilling procedures for the borings converted to soil-vapor wells are discussed in Section 3.4.1. A typical schematic for the dual wall percussion hammer drilling method is presented in Figure 3-6.

3.3.1.2 Sonic

Following the introduction of "sonic" (synonyms include rotasonic, rotonic, rotary sonic, sonicare, and resonantsonic) drilling equipment into the southern California area, soil vapor well Nos. 24 through 39 were drilled using sonic methods. This was the preferred method as it produces a much smaller quantity of drill cuttings than other methods, allows continuous cores of the subsurface materials to be collected, and the waiting period for soil-vapor sampling can be significantly reduced. When drilling methods use compressed air to circulate drill cuttings out of the borehole, the air pressure also forces soil vapor back into the formation, and a waiting period of 2 months was required for the soil vapor to return to equilibrium before sampling.

Sonic drilling techniques use a hydraulically driven head that imparts adjustable high frequency sinusoidal wave vibrations into the drill rods and core barrel, plus the outer casing, to create a cutting action at the bit face. When required, the drill rods and casing were rotated to evenly distribute the energy and the wear on the drill bit face. Because of the high force developed by the vibrating drill head (up to more than 200,000 pounds) and applied vertical load, the drill string "fluidized" and displaced excess formation material into the boring wall and core resulting in no excess cuttings being generated during the drilling operations. Continuous cores of subsurface materials were retrieved using a 10-foot-long, 6-inch-diameter core barrel.

The system required neither the addition of air nor drilling fluids for penetrating soil materials, cobbles, or boulders.

The outer casing was advanced after the core barrel moved ahead to collect the core sample and then pulled out of the borehole. This procedure left a cavity so that cuttings that are "shaved" from the borehole wall as the outer casing is being advanced can be collected, thus minimizing soil compression and friction with the surrounding soil materials. These shaved cuttings were then removed from inside the casing, or from the open hole below the bottom of the casing, before the next length of core was collected.

Lengths of core runs ranged from 1 to 10 feet based on the amounts of penetration resistance experienced in advancing the core barrel. High resistance resulted in shorter core runs to prevent excessive heat from developing in the core. This procedure was carefully followed to comply with DTSC's request (JPL, 1996) to keep core temperatures as low as possible.

Borehole integrity was maintained by the casing after the drill string was pulled from the hole and during installation of the soil-vapor wells. Procedures for the placement of backfill materials are discussed in Section 3.4.1. A typical schematic for the sonic drilling method is shown in Figure 3-7.

All downhole drilling equipment (i.e., casing, core barrels, bits, and drill rods) and the drilling platform on the drill rig were steam cleaned between boreholes. Soil cuttings and logged soil cores were placed temporarily in 55-gallon drums at each drilling location and transferred to 15-cubic-yard roll-off bins at the end of each day.

3.3.1.3 Hollow Stem Auger

Hollow stem auger is an ideal method for drilling through unconsolidated alluvial sediments including sands, silts and clays. This particular technology employs flighted tubing and rotation to advance through the formation and remove soil cuttings. The hollow tubing maintains the integrity of the borehole and facilitates soil sampling or well installation.

The hollow stem auger drilling technique uses a truck mounted hydraulically driven head that generates up to 31,000 foot-pounds of torque to rotate flighted hollow tubing into the subsurface. The constant rotation of the flighted tubing and down hole pressure created by the drill rig displaces the soil cuttings up the exterior of the hollow tubing to the surface where the cuttings are manually placed into a roll-off bin or 55-gallon drums. This system requires neither the addition of air nor drilling fluids to penetrate through the subsurface or to displace soil cuttings. Borehole integrity was maintained by the flighted tubing while soil samples were collected using a split-spoon sampler.

Soil borings BG-1, BG-1A, BG-2, and BG-2A were drilled with a CME 95 conventional hollow stem auger drilling rig to obtain background soil samples for chemical analysis at the locations shown in Figure 3-8. The hollow stem auger sections were 5 feet long with a flight diameter of

8 1/4 inches and an inside diameter of 4 1/4 inches. When the desired sample depth was reached, the bit plug was removed from the bottom of the drill string and a soil sample was collected.

The augers and bits were steam cleaned prior to drilling each soil boring. Since the boreholes were drilled for the collection of background samples at locations with no history of potential contamination, the soil cuttings were used to backfill the boreholes. The asphalt pavement at these locations was patched with like materials.

3.3.1.4 Storage and Disposal of Drill Cuttings

All drill cuttings generated during the OU-2 field investigation were collected and temporarily stored. During drilling activities, the soil cuttings were placed in 55-gallon drums or roll-off bins pending proper characterization for transport and disposal purposes. Analytical results for soil samples collected from the roll-off bins were used to determine the proper method of disposal pursuant to the EPA guidance on the management of investigation-derived waste (EPA, 1991 and 1992).

All of the drill cuttings or soil samples generated during the OU-2 remedial investigation were determined to be non-hazardous and were disposed of accordingly.

3.3.2 Soil Sampling Methods

Soil samples for chemical and geotechnical analyses were collected by using a conventional split-spoon sampler or manually with stainless steel trowels and spoons. Prior to collection of a soil sample by either method, all sampling apparatuses (samplers, bits, stainless steel sleeves, and hand tools) were decontaminated by double washing in a solution of non-phosphate detergent (Liquinox®) and deionized water and then in a solution of an acid detergent (Citranox®) and deionized water. The washings were followed by a double rinse in deionized water, and then the sampling equipment was allowed to air-dry prior to use.

3.3.2.1 Split-Spoon Method

Relatively undisturbed soil samples were collected from soil boring Nos. 1 through 24 and Nos. 29 through 31 at approximately 10-foot intervals beginning at a depth of 10 feet. However, the final intervals between samples in each boring were based primarily on the success of driving the split spoon sampler through gravelly materials. Depths at which samples were collected in each borehole including the laboratory analyses performed on each sample, are presented in Table 3-5, and analytes reported for each analytical method are listed in Table 3-6. Soil samples were collected with a split-spoon sampler following the procedures described below.

Percussion Hammer

- Each borehole was drilled to the desired sampling depth using the percussion hammer drill rig with dual-wall drive pipe and reverse-air circulation. The dual-wall drive pipe was not driven below the prescribed sampling depth.

- A 2.5-inch-ID by 18-inch-long split-spoon sampler containing three decontaminated stainless steel sample sleeves (6.0 inches long and 2.5 inches in outside diameter) was attached to cable tool slip jars and lowered down through the middle of the dual-wall drive pipe to the sampling depth. The sampler was then driven into the soil a maximum of 18 inches beyond the drill bit using the slip jars whose vertical drive stroke was limited to 24 inches. Because of difficulties experienced while driving samplers with a 140-pound slide hammer during the drilling of groundwater monitoring wells at the site, the choice to use slip jars instead of a 140-pound slide hammer for split-spoon soil sample collection was initiated. The slip jars weighed approximately 1,000 pounds and have a maximum stroke of 28 inches and are normally used to drill wells with a cable-tool type of drill rig.
- The sampler was then retrieved and opened. Whenever possible, the uppermost sample sleeve was used for lithologic description purposes, the middle sleeve for quality-control purposes, and the lowermost sleeve for laboratory analysis. The ends of the soil sample designated for laboratory analysis were trimmed, covered with Teflon® sheets, and capped with tightly fitting plastic end caps. After the sample was labeled, it was sealed in a plastic bag and placed on ice in a cooler prior to being transported to the laboratory. Samples used for lithologic descriptions were monitored for the presence of organic vapors with an OVA. This was completed for data acquisition purposes as well as for health and safety monitoring. Measured values were recorded on the field boring log forms.

Sonic

- Each soil boring was drilled to the desired sampling depths with a 6-inch-diameter core barrel attached to 2 3/8-inch-diameter drill rods. Once the desired sampling depth was reached, the core barrel and drill rods were removed from the borehole (integrity of borehole was maintained by the outer casing.)
- A split-spoon sampler containing three decontaminated stainless steel sample sleeves (6.0 inches long and 2.5 inches in outside diameter) was attached to the drill rods in place of the core barrel and lowered down the hole. The sampler was advanced into the soil by vibrating the drill rods and sampler under the weight of the drill head.
- The sampler was then retrieved and opened. Because the number of laboratory analyses had been increased over those for the previous sampling event, a larger volume of soil was needed by the laboratory for chemical analysis. Therefore, both the lowermost and middle sample sleeves were submitted. The uppermost sleeve was used for lithologic description purposes in conjunction with observations of the retrieved core. The ends of the soil samples designated for laboratory analysis were trimmed, covered with Teflon® sheets, and capped with tightly fitting plastic end caps. After the sample was labeled, it was sealed in a plastic bag and placed on ice in a cooler prior to being transported to the laboratory. All soil cores retrieved were placed directly into plastic sleeves as the core was being removed from the core barrel. Prior to opening the plastic sleeves for visual examination and lithologic description, the probe of a flame-ionization detector (FID) was inserted into the plastic sleeve to monitor for the presence of organic vapors. This was completed for data acquisition purposes as well as for health and safety monitoring. Measured values were recorded on the field boring log forms.

Hollow Stem Auger

- The background-sample boreholes were drilled to depths ranging from 17 to 24 feet. After reaching the sampling depth, the auger bit plug was removed, by a wire line, from the bottom of the drill string. All auger sections were left in place to stabilize the borehole.
- A 2.5-inch-ID by 18-inch-long split-spoon sampler containing three decontaminated stainless steel sampling tubes (6-inches long and 2.5-inches in outside diameter) was attached to 1.75-inch diameter drill rods and lowered through the middle of the hollow stem auger to the bottom of the borehole. The sampler was then driven into the soil a minimum of 18 inches beyond the end of the drill bit using a 140-pound sliding hammer with a 30-inch vertical stroke.
- Upon retrieval, the sampler was opened and the uppermost of the 6-inch stainless steel sampling tubes was used for lithologic description, the middle tube for quality assurance/quality control, and the lowermost tube was sent to the laboratory for analysis. The ends of the sampling tubes designated for laboratory analysis were trimmed, covered with Teflon® sheets, and capped with tightly fitting end caps. The samples were then labeled, placed in a sealable plastic bag, and stored on ice in a cooler prior to transport for laboratory analysis. Since there was no possibility of these samples being contaminated by any JPL activities, they were not monitored for organic vapors.

3.3.2.2 Grab Sample Method

In addition to split-spoon sampling, grab samples were also collected from six test pit excavations and at locations where poor soil recovery was encountered while using the split-spoon samplers.

Soil Borings

Because of poor recovery using split-spoon samplers, grab samples were collected for chemical analysis from soil boring No. 29 at depths of 10, 20, 49, 70.5, and 79.5 feet. These grab samples were collected from the plastic sleeves containing continuous soil cores from the core barrel. Based on discoloration, an additional grab sample from the core of soil boring No. 29 was collected at the 4-foot interval. Inadequate soil sample recovery with the split-spoon sampler in soil boring No. 30 resulted in the collection of grab samples from the core at depths of 49.5 and 69.5 feet.

Test Pits

On April 14, 1997, three test pits were excavated to a target depth of 5 feet using a backhoe. All three test pits were located along the western bank of the Arroyo Seco near three JPL storm-drain outfalls described in the "Part B" Addendum to the FSAP (FWENC, 1996d). Test pit No. 1 (TP-1) was excavated near outfall DP-4 (Figure 3-1) just north of the southeastern corner of Building 103. Test pit No. 2 (TP-2) was located near outfall DP-1 south of Building 103. Test pit No. 3 (TP-3) was located near outfall DP-3, in an area now near the current 48-inch-diameter outfall south of the Southern California Edison Substation, on the east side of the parking lot.

During the formal data-validation process, it was discovered that holding times were exceeded for the PAH, dioxin, and tributyltin analyses conducted on the samples from test pit Nos. 1, 2, and 3. All "not detected" results were rejected and any detects reported for these analyses were qualified as "estimated." In addition, the laboratory reported "no recovery" on their hexavalent chromium matrix spike laboratory control sample for the six test pit samples. Hence, the "not detected" results for hexavalent chromium were rejected. As a result of these rejected and estimated values, the test pits were reexcavated on June 10, 1999, at the same locations described above, and the new test pits are designated TP-1A, TP-2A, and TP-3A.

Two grab samples were obtained from each of the six test pits at the depths listed in Table 3-7. The soil samples were collected manually using stainless steel trowels and a stainless steel spoon to collect the finer grained materials from between cobbles and boulders. The soil samples were packed into 4-, 8-, and 16-ounce glass jars and the Teflon™ lined lids were tightened securely. Because of the large volume of soil needed to perform all the required chemical analyses, two or more jars were filled to make one sample. After the sample jars were labeled, they were sealed in a plastic bag and placed on ice in a cooler before being transported to the laboratory.

3.3.2.3 Decontamination Procedures

All of the equipment used in the collection of soil samples during the OU-2 RI was decontaminated prior to use. The sampling equipment, including split-spoon samplers and sample sleeves were washed with a Citronox® or Liquinox® (non-phosphatic detergents) solution, followed by a double rinse with deionized or distilled water, and air dried before use. Wastewater from the decontamination process was stored in a portable tank until which time it could be sampled and analyzed for proper disposal.

3.3.3 Soil Sample Analyses and Handling Procedures

All soil sample analyses and handling procedures conducted during the OU-2 RI field programs were performed in strict accordance with the FSAP (Ebasco, 1993d) and the addenda for the FSAP (FWENC, 1996c and 1996d) and QAPP (Ebasco, 1993e and 1996e). Analytes reported for each method of analysis are listed in Table 3-6.

3.3.3.1 Soil Sample Analyses

Soil samples collected from soil boring Nos. 1 through 24 were transported each sampling day by special courier to Analytical Technologies, Inc., a state-certified laboratory in San Diego, California, for analysis. Chemical analyses performed included those for SVOCs (EPA Method 8270), Title 26 Metals (formerly CAM 17 Metals) plus strontium and hexavalent chromium (EPA Methods 6010/7000 series), cyanide (EPA Method 9010), TPH (EPA Method 418.1), nitrate (EPA Method 300.0), and total solids for percent moisture (EPA Method 160.3). In addition, samples from soil boring No. 19 were analyzed for radioactivity (gross alpha and beta) by EPA Method 900.0.

Soil samples collected from soil boring Nos. 29 through 31 and test pit Nos. TP-1, TP-2, and TP-3 were air freighted each sampling day by a representative of Intertek Testing Services (formally Inchcape Testing Services) to their state-certified analytical laboratory in San Jose, California for analysis. For analyses that Intertek Testing Services (Intertek) could not perform in their San Jose laboratory, samples were forwarded to two other CDHS-certified laboratories that specialize in certain chemical analyses.

Analyses performed by Intertek Testing Services at their San Jose laboratory included those for SVOCs (EPA Method 8270), Title 26 Metals plus strontium and hexavalent chromium (EPA Methods 6010/7000 series), cyanide (EPA Method 9010), PCBs (EPA Method 8082), TPH (EPA Method 418.1), nitrate (EPA Method 300.0), and total solids for percent moisture (EPA Method 160.3). The San Jose laboratory also analyzed samples from test pit Nos. 1, 2, and 3 for VOCs (EPA Method 8240). Intertek's sister laboratory, located in Colchester, Vermont, analyzed the samples from soil boring Nos. 29 through 31 and the samples from test pit Nos. 1, 2, and 3 for PAHs (EPA Method 8310) and tributyltin (there is no approved EPA analytical method for this compound). The analysis for polychlorinated dibenzodioxins and furans (EPA Method 8280) was subcontracted by Intertek to Triangle Laboratories, Inc. in Durham, North Carolina, a laboratory that specializes in performing this particular type of analyses.

Samples from test pit Nos. TP-1A, TP-2A, and TP-3A were sent by a representative of Quanterra, Incorporated to their state-certified laboratory in West Sacramento, California. Analyses performed by Quanterra, Incorporated at their West Sacramento laboratory included those for SVOCs (EPA Method 8270), Title 26 Metals plus strontium (EPA Method 6010/7000 series), cyanide (EPA Method 9010), PAHs (EPA Method 8310), PCBs (EPA Method 8082), VOCs (EPA Method 8260), nitrate (EPA Method 300.0), and total solids for percent moisture (EPA Method 160.3). The analyses for hexavalent chromium (EPA Method 7199/3060A) and tributyltin (there is no EPA-approved method for this analysis) was subcontracted by Quanterra to West Coast Analytical Service, Inc. in Santa Fe Springs, California.

Background samples were collected in April 1994 from soil borings BG-1 and BG-2 as part of the installation of monitoring wells for the OU-1 RI. These two samples were analyzed for Title 26 Metals plus strontium (EPA Methods 6010/7000 series), VOCs (EPA Method 8240), and SVOCs (EPA Method 8270) by Montgomery Watson Laboratories (Montgomery) in Pasadena, California. Montgomery is certified by the CDHS for the analyses performed. Following these analyses, it was learned that the DTSC would consider the reported total chromium concentrations to be hexavalent chromium since the samples from these borings were not analyzed exclusively for hexavalent chromium. Because of the decision by the DTSC, soil borings BG-1A and BG-2A were drilled and sampled within several feet of the original boring locations as part of the first OU-2 drilling program. Samples from these two new soil borings were analyzed for hexavalent chromium (EPA Method 7196), as well as Title 26 Metals plus strontium, by Analytical Technologies, Inc.

3.3.3.2 Sample Handling Procedures

Sample labels were attached to each sample sleeve or glass jar after sample collection. After collection, custody seals and sample tags were also added to each sample container as described in the QAPP (Ebasco, 1993e). The sample containers were then sealed in self-locking plastic bags to prevent the loss of labels during shipment. All samples were placed in a cooler with ice so they would remain at a temperature of 4°C until delivery to the laboratory. Glass sample containers were packaged with bubble wrap to avoid breakage.

Chain-of-custody procedures were used to maintain and document sample possession for legal purposes. Adherence to strict document control procedures was of prime importance. The principal documents that were used to record possession of the samples were the chain-of-custody forms and the bound field logbooks. A sample was considered to be in a person's custody if (1) it was in a person's physical possession, (2) it was in view of the person after that person had taken possession, (3) it was secured by that person so that no one could tamper with the sample, and (4) it was secured by that person in an area in which access was restricted.

Chain-of-custody forms were completed and accompanied all samples to the laboratory. The field sampler (originator) was responsible for the care and custody of the samples from the time they were collected until they were transferred to another individual. All samples were transported to the laboratory by the laboratory's representative or other authorized personnel, ensuring prompt, secure arrival and meeting the requirements of chain-of-custody procedures. For each sample shipment, the originator completed a chain-of-custody form entering all the requested information. At a minimum the form contained the following:

- Sample number(s)
- Signature of sampler
- Date and time of sample collection
- Sample type
- Signature of persons involved in the chain of possession
- Date and time of relinquishment
- Analyses required

At the transporter's request, authorized sampling personnel were available to open shipping containers for inspection or to modify packaging. Persons relinquishing samples signed the chain-of-custody form in the appropriate box labeled "relinquished by" and retained a copy. The sample recipient cross-checked the sample label and the chain-of-custody form. Persons relinquishing and receiving the sample signed the chain-of-custody in the appropriate boxes labeled "relinquished by" and "received by" respectively. Along with their signatures, they noted the date and time of the exchange. A copy of the chain-of-custody form accompanied all sample shipments. The original and remaining copies were maintained in a project file.

3.3.4 Investigation-Derived Waste

During the OU-2 RI drilling programs, grab samples of the soil cuttings were collected from the roll-off bins to characterize the cuttings for disposal purposes only. Similarly, decontamination water were also collected and characterized for disposal purposes.

Grab samples of soil cuttings were obtained from all four corners of each roll-off bin by removing approximately 1 foot of soil and then using four sterile 4-ounce, wide-mouth glass jars to scoop out samples from the bottoms of each cleared-off area. Thus, four jars were collected from each bin for compositing by the laboratory. All soil cuttings sample jars were tightly capped with Teflon-lined lids, labeled and tagged, sealed in a self-locking plastic bag, and placed on ice in a cooler immediately after sampling.

Water used for decontaminating the drilling equipment was collected by berms around the decontamination pad and then pumped into a 4,000-gallon Baker® tank adjacent to the pad. At the completion of each drilling program, samples of the decontamination water were collected in 1-liter glass bottles and 40-milliliter vials. The containers were tightly labeled, tagged, wrapped in bubble wrap, sealed in self-locking plastic bags, and placed on ice in a cooler immediately after sampling.

All soil cuttings were analyzed for Title 26 Metals plus strontium (EPA Methods 6010/7000 series) and TPH (EPA Method 418.1) while the water samples were analyzed for Title 26 Metals plus strontium (EPA Methods 6010/7000 series) and for halogenated and aromatics volatile hydrocarbons (EPA Methods 8010/8020) to determine disposal options for the disposal of these wastes pursuant to EPA's guidance on the management of investigation-derived wastes (EPA, 1991c and 1992a).

Soil cuttings generated during the OU-2 drilling programs were arranged to be disposed of by JPL at Laidlaw Environmental Services' Class II landfill facility in Buttonwillow, California. The decontamination fluids generated during the OU-2 RI were arranged to be disposed of by JPL at Southwest Processor's facility in Vernon, California.

3.4 SOIL VAPOR WELL INSTALLATION AND SAMPLING PROGRAM

During the first phase of subsurface exploration for the OU-2 RI, nested soil vapor monitoring wells were installed in 25 of the 28 soil borings drilled at potential contaminant source locations. The locations of these soil-vapor wells are shown in Figure 3-9. Soil-vapor wells were not installed in soil boring Nos. 19, 23, and 23A for the following reasons:

- The percussion hammer rig was not able to penetrate a boulder at a depth of 46 feet in soil boring No. 19 and so the hole was abandoned. A step-out boring (No. 19A) was drilled 6 feet west of the original location, completed to target depth of 100 feet, and a soil-vapor well was installed.

- The inability to collect shallow soil samples from soil boring No. 23 with a split-spoon sampler prompted another attempt with a step-out boring (No. 23A) 6 feet southwest of the original location. Only one sample, at a depth of 1.5 feet, could be collected from this boring because of the high gravel and cobble content in the soil. A second step-out boring (No. 23B) was drilled 4.5 feet southwest of soil boring No. 23A; again, only rock fragments were recovered in the split-spoon sampler. Since groundwater was encountered at a depth of 23.5 feet in soil boring No. 23A and the drilling equipment was unable to penetrate a boulder in No. 23, it was decided by NASA's Designated Project Manager to install the soil-vapor well in No. 23B and to not drill any more borings at this location.

These three soil borings (Nos. 19, 23, and 23A) were backfilled with bentonite granules from total depth to within 2 feet of the ground surface and then finished with asphalt at No. 19 and gravelly soil at Nos. 23 and 23A.

Following two rounds of soil-vapor sampling and analysis (Events 2 and 3), it was apparent that elevated concentrations of VOCs (predominantly carbon tetrachloride) existed in soil vapor well No. 16. These VOC concentrations increased with depth and was indicative that the well could possibly be located near a potential contaminant source area. Because the bottom of soil vapor well No. 16 was estimated to be 100 feet or more above the groundwater table, it was possible that high VOC concentrations could occur in the vadose zone beneath the well and be a source of groundwater contamination. As described in the addenda to the RI/FS work plan (FWENC, 1996a) and the OU-2 FSAP (FWENC, 1996e), four deep soil-vapor wells (Nos. 25, 26, 27, and 28) were drilled and installed at the locations shown in Figure 3-10 to further assess the horizontal and vertical extents of VOC vapors in the vicinity of soil vapor well No. 16. Each well was drilled to the capillary fringe above the groundwater table with a Roto-Sonic 150 drilling rig before the soil vapor well components were installed.

Results from the sampling and analysis Events 4 and 5 indicated that all four of the new deep soil-vapor wells (Nos. 25, 26, 27, and 28) had been installed in an apparent soil-vapor plume. Elevated concentrations of total VOCs predominated by carbon tetrachloride were encountered in each of the new deep wells. Based on these results and on discussions held at the RPM meetings on September 4 and December 3, 1997, it was determined that additional characterization of VOC vapors in the vadose zone at JPL was required.

The highest VOC concentrations in groundwater beneath JPL have been detected in samples collected from shallow groundwater monitoring wells MW-7, MW-13, and MW-16 (see Figure 3-11). Well MW-7 is in close proximity to the soil-vapor plume encountered by soil vapor well Nos. 25, 26, 27, and 28, and the contaminants detected in MW-7 may be attributable to that plume. Similarly, contaminants detected in groundwater samples from MW-13 and MW-16 might be the result of another soil-vapor plume, or plumes, in the general area of these shallow groundwater wells. In order to further characterize the horizontal and vertical extents of the soil-vapor plume near MW-7, deep soil vapor monitoring wells (Nos. 32, 33, 34, and 35) were drilled and installed at the locations shown in Figure 3-11. Since previous vadose-zone

explorations in the vicinities of groundwater monitoring wells MW-13 and MW-16 were limited to, respectively, soil vapor well Nos. 19A and 8 (neither soil-vapor well extends to the capillary fringe above the groundwater table), four deep soil-vapor wells (Nos. 36, 37, 38, and 39) were installed and sampled to assess the possibility of groundwater in the vicinities of MW-13 and MW-16 being contaminated by VOC vapors in the vadose zone. All eight deep wells were drilled to the top of the capillary fringe above the groundwater table with a Roto-Sonic 150 drilling rig before the soil vapor well components were installed.

3.4.1 Installation of Soil-Vapor Wells

During the OU-2 RI, a total of 40 soil-vapor wells (Nos. 1 through 18, 19A, 20, 20A, 21, 22, 23B, and Nos. 24 through 39) were installed and sampled. Because two different types of drilling equipment (percussion hammer and sonic) were used to drill the wells, construction methods to install the wells differed although the final installations were equivalent to one another. A typical schematic diagram for soil vapor well construction is shown in Figure 3-12. Construction diagrams for all soil-vapor wells are presented adjacent to the boring logs in Appendix A. Procedures for constructing the soil-vapor wells are discussed in the following subsections.

3.4.1.1 Soil Vapor Well Nos. 1 through 24

A percussion hammer drilling rig that utilized dual-wall drive pipe was used to install a total of 25 soil-vapor wells (including well Nos. 20 and 20A). The inner pipe allowed the placement of all sampling tips and tubing in each well simultaneously, as well as being a tremie for solid backfill materials (sand and bentonite granules). The annulus between the pipes was used to add hydration water to the bentonite during backfilling. Installation of soil vapor well Nos. 1 through 24 were completed according to the following general procedures:

- The total depth of each well was determined by the NASA Authorized Subcontractor Operable Unit Manager (OUM) based on reaching the planned total depth of the well, inability of the drill rig to penetrate boulders or encountering bedrock, the capillary fringe above the groundwater table, or perched water.
- The numbers of sampling tips (a maximum of five per well) and the depths at which they were to be placed in each well were determined in the field based on soil lithologies, OVA measurements on soil samples, and total open-depth of the borehole.
- Based on the total depth of the well, the sampling tips and attached 1/8-inch-OD Nylaflow® tubing were secured at field-determined intervals with cable ties to a varying number of 20-foot-long sections of 1/2-inch-diameter Schedule 40 PVC pipe laid out on the ground surface. The PVC hanger pipe and the tubing for each sampling tip were assembled so that the pipe (with a bottom cap) and tubing would extend a minimum of 5 feet above the ground surface after placement in the well. The surface ends of the Nylaflow® tubing were color coded with paint to identify the sequential number and depth of each sampling tip before the assembly was placed in the borehole; no coloring indicated the shallowest tip, and the color

sequence of green, red, blue, and black indicated the progression of sampling-tip placement with depth.

- Flexibility of the 1/2-inch-diameter PVC pipe allowed all of the sampling tips and tubing to be placed simultaneously by arching the assembly into the center of the dual-wall drive pipe and lowering it to the bottom of the well. Centralizers were not required because the inner pipe of dual-wall drive pipe centralized the assembly.
- The dual-wall drive pipe was used as a tremie pipe for backfilling operations. Sand and pure bentonite granules were placed by pouring these materials into the inner pipe; 2 to 3 gallons of potable water, used to artificially hydrate the bentonite, was added through the annulus between the inner and outer pipes at the middle of each bentonite section. The rest of the bentonite was naturally hydrated by absorbing soil moisture from the surrounding formation. During the backfilling operations, the dual-wall drive pipe was removed from the borehole one section at a time.
- Annular spaces between the hanger pipe-sampling assembly and the borehole wall were backfilled with clean, kiln-dried RMC Lonestar® #3 sand and either Enviroplug® No. 16 or Benseal bentonite granules (Benseal® is equivalent in granular size to Enviroplug® No. 16). A minimum of 1 foot of sand was placed below and above each sampling tip, and the intervals between the sand were backfilled with bentonite granules hydrated in-place with potable water. Similarly, the annular space above the uppermost sampling tip was backfilled with hydrated bentonite granules to within 2 feet of the ground surface. When backfilling was completed, the hanger pipe was cut off approximately 4 to 6 inches below the ground surface and the Nylaflo® tubings were sealed with air-tight, 1/8-inch Swagelok® tubing caps. The backfilling procedure was continuously monitored with a weighted tape measure while backfill materials were being placed.
- A 12-inch-diameter traffic box was installed at each soil-vapor well. Concrete was used to secure the traffic box in-place slightly above grade in such a way as to direct surface runoff away from the box's cover plate. Additional sand was then placed above the hydrated bentonite to complete the backfilling operation.
- Following the installation of the soil vapor well assembly and traffic box, the interiors of the PVC hanger pipes were backfilled from bottom to top by incrementally placing Benseal® in the pipe and hydrating each increment with deionized water via 5/16-inch-diameter polyethylene tubing.

3.4.1.2 Soil Vapor Well Nos. 25 through 39

A Roto-Sonic 150 drilling rig was used to install soil vapor well Nos. 25 through 39. Since this drilling method was limited to only the outer casing for maintaining the integrity of the borehole walls, installation procedures for installing the soil vapor well components differed from those for soil vapor well Nos. 1 through 24. Construction methods for installing soil vapor well Nos. 25 through 39 were completed according to the following general procedures:

- The total depth of each well was determined by the NASA Authorized Subcontractor OUM for OU-2 based on the depth where groundwater was encountered in the borehole or when perched groundwater was unexpectedly encountered.

- The numbers of sampling tips (a maximum of ten per well) and the depths at which they were to be placed in each well were determined in the field based on soil lithologies, FID measurements made through the plastic bags enclosing the soil cores, and the final open-hole depths of the borehole.
- Since either groundwater or perched groundwater was encountered in all of these soil-vapor wells and accumulated in the bottom of each borehole, 1/4-inch bentonite pellets were used to absorb the water and keep the bottom of the borehole in a dry condition as deeply as possible. Depending on the stabilized water levels, varying amounts (1.1 to 6.5 cubic feet) of pellets were added to the bottoms of the boreholes. One cubic foot of dry pellets raises the borehole bottom 3.5 feet (not allowing for expansion due to hydration). A weighted sounding line was used to evaluate the dryness of the borehole's bottom; if the retrieved weight was clean, it indicated that dry bentonite was at the bottom of the open borehole. The bottom was resounded when well installation started 1 to 2 hours later.
- A hanger pipe, consisting of 10-foot lengths of 1-inch-diameter Schedule 80 PVC pipe was placed to the bottom of the borehole before the sampling tips and 1/8-inch-OD Nylaflow® tubing were installed. The interior of each hanger-pipe section was incrementally backfilled from bottom to top with Enviroplug® No. 16 bentonite granules and each increment was hydrated with deionized water via 5/16-inch-diameter polyethylene tubing as each pipe section was being lowered into the soil-vapor well.
- Because of only having the outer casing to stabilize the borehole walls, all sampling tips and attached Nylaflow® tubing had to be installed individually for each sampling depth. Sampling tips and tubing were weighted with 6-inch lengths of 1/4-inch-diameter galvanized pipe and lowered to their field-determined depths and suspended from the top of the hanger pipe assembly.
- The surface end of each Nylaflow® tubing was coded with either a single or double band of colored plastic tape to identify the sequential number and depths of each sampling tip placed in the soil-vapor well. A single band of yellow tape indicated the shallowest tip (tip No. 1) and a double band of black tape identified the deepest tip (tip No. 10). Single bands of green, red, blue, and black tape were used to sequentially identify tip Nos. 2 through 5, respectively, and double bands of yellow, green, red, and blue were used to identify the number and progressive depths of sampling tip Nos. 6 through 9, respectively.
- Annular spaces around the sampling tips with attached Nylaflow® tubing and the borehole walls were backfilled with clean, kiln-dried RMC Lonestar® #3 sand and Enviroplug® No. 16 pure bentonite granules. A minimum of 1 foot of sand was placed below and above the sampling tip, and the intervals between the sand were backfilled with bentonite granules that were artificially hydrated with 2 to 3 gallons of potable water in the middle of each bentonite section. The remainder of the bentonite hydrated naturally by absorbing soil moisture from the surrounding formation. The annular space above the uppermost sampling tip was backfilled with bentonite granules (hydrated in place) to within 2 feet of the ground surface. Upon completion of backfilling, the hanger pipe was cut off approximately 4 to 6 inches below the surface of the surrounding surface area and the color-coded Nylaflow® tubings were sealed with air-tight, 1/8-inch Swagelok® tubing caps.

- A 12-inch-diameter traffic box was installed at each soil-vapor well. Concrete was used to secure the traffic box in-place slightly above grade so as to direct surface runoff away from the traffic box's cover plate.
- After the soil vapor well assembly and traffic box were installed, the remaining open portion of the drillhole (1 to 2 feet) was filled with sand to complete the soil vapor well installation.

3.4.2 Sampling of Soil-Vapor Wells (Events 2 through 7)

Soil-vapor samples from soil vapor well Nos. 1 through 24 were collected and analyzed in December 1994 (Event 2) and again during March 1995 (Event 3). Events 4 and 5 involved the collection and analysis of soil-vapor samples from well Nos. 25 through 31 during, respectively, June 1997 and then again in July 1997. Soil-vapor samples collected and analyzed during May 1998 (Event 6) were from soil vapor well Nos. 25 through 28 and Nos. 32 through 39. A second round of sampling and analysis of samples from well Nos. 32 through 39 were completed during Event 7 in June 1998.

Sampling analyses conducted during Events 2 through 7 were essentially the same as those described in Section 3.2.2 for Event 1, the main difference being that trichlorotrifluoroethane (Freon 113) was added to the required analyte list by the California Regional Water Quality Control Board, Los Angeles Region (RWQCB), during the time interval between Events 1 and 2.

Soil-vapor samples were withdrawn from the soil through the sampling tips and 1/8-inch-OD Nylaflo® tubing using calibrated, gas-tight, 20-cc and 60-cc sterile syringes fitted with a three-way on-off valve. The 20-cc syringes were used when the sampling tips were less than 20 feet deep and the 60-cc syringes were used when the tips were at depths of 20 feet or more. Prior to collecting the soil-vapor sample, four volumes of the length of the tubing were purged to flush the tubing and fill it with in-situ soil vapor. Since each foot of tubing has an internal volume of 1 cc, the total volume purged was easily measured with the calibrated syringes. Following purging, either a 20-cc or 60-cc soil-vapor sample was collected in the syringe, the valve turned to the off position, and transferred immediately to the on-site mobile laboratory for analysis. During sampling Events 2 through 7, neither water vapor nor condensation was observed in the transparent sampling syringes. Because the purge and sample volumes were small, a vacuum pump was not required to evacuate the tubing or to collect a soil-vapor sample. To demonstrate reproducibility of results, a duplicate soil-vapor sample was collected and analyzed after every five samples.

Samples collected during these events were analyzed on-site in two mobile laboratories certified by the CDHS to perform analyses by EPA Methods 8010 and 8020 for the parameters listed in Table 3-3. The first mobile laboratory (Certification No. 1667), used during Event 2 and 3, was the same laboratory utilized during Event 1. A second laboratory (Certification No. 1745) was used to analyze all soil-vapor samples collected during Events 4 through 7.

3.5 DATA QUALITY ASSURANCE/QUALITY CONTROL

Field quality control (QC) checks were applied throughout the OU-2 RI to verify the analytical results of the samples collected. Quality control checks included field QA/QC samples, laboratory QC samples, and data validation. These measures were implemented in order to comply with the project requirements proposed in the QAPP (Ebasco, 1993e) and to ensure that the project Data Quality Objectives (DQOs) were met.

The development of data quality objectives (DQOs) for this investigation is described in the project QAPP (Ebasco, 1993e) and the RI/FS work plan (Ebasco, 1993a). Overall, the fundamental goals of the project DQOs were to acquire data of sufficient quantity and quality to achieve the following results:

- Determine the nature and extent (both vertical and horizontal) of the constituents of interest in the soil and soil vapor.
- Support a risk assessment and address significant exposure pathways.
- Support decisions for potential remedial alternatives and remedial design.

3.5.1 QA/QC for the Initial Soil-Vapor Survey

Descriptions of the specific quality control checks associated with the initial soil-vapor survey conducted as part of the OU-2 RI are presented in the following subsections. The QA/QC measures listed below were applied to the collection and analysis of soil vapor probe samples related to the initial soil-vapor survey.

3.5.1.1 Field QA/QC

Field quality control during this phase of the investigation included the collection of duplicate soil vapor probe samples and field blanks. Approximately one duplicate was collected for every five environmental samples. Duplicates consisted of a second sample collected from the same location and depth as the corresponding original sample and were analyzed for the same constituents as the original sample to help assess the precision of the sampling and laboratory analytical procedures. Field blanks consisted of ambient air samples collected from within the mobile lab near the instrumentation. One field blank was collected at the beginning of each sampling day and analyzed for the same constituents as the environmental samples to determine potential influence of ambient conditions on the analytical results.

3.5.1.2 Mobile Laboratory QA/QC

All soil vapor probe samples were analyzed on-site in two CDHS-certified mobile laboratories equipped with laboratory-grade gas chromatograph instrumentation. The first laboratory (Certification No. 1667) was used during sampling event Nos. 1, 2, and 3, and the second laboratory (Certification No. 1745) was used during sampling event Nos. 4 through 7. Instrument operating conditions and parameters were optimized at all times to provide maximum analytical

performance. In addition, the following QA/QC procedures for the soil-vapor analysis were conducted in accordance with the requirements issued by the RWQCB (October, 1992).

Initial Calibration

An initial calibration was performed for all of the compounds listed in the QAPP (Ebasco, 1993e, Appendix A). A minimum of three concentrations were performed with the lowest concentration being no higher than three times that of the method detection limit (0.1 to 1.0 µg/l). Identification and quantification of compounds were based on the same operating conditions of the instrument as they were during the calibration using the same column and detector at the same temperature, gas flow, and other parameters. Any changes in instrumental or experimental conditions resulted in a new initial calibration procedure.

Daily Calibration

A single-point (mid-point) calibration sample, containing nine calibration standards, including three aromatic and six halogenated compounds, were analyzed at the beginning of each working day. These compounds were selected to represent the short, medium, and long retention-time groups of compounds listed in the QAPP (Ebasco, 1993e, Appendix A). This single-point calibration check was performed for all compounds detected. If a detected compound was not on the list of calibration compounds, an additional calibration was performed for that compound. To ensure optimal instrument performance, the response factors for the daily calibration compound had to be within 15 percent of the corresponding value for the three-point (initial) calibration, otherwise the GC was re-calibrated.

Blanks

Blank samples, such as ambient air, were designed to monitor cross contamination that may have occurred due to sample handling, instrument carry-overs, or general environmental conditions. All blanks were analyzed at the beginning of the working day and as frequently as required throughout the rest of the day.

Quality Control (QC) Check Sample

A minimum of two QC check samples were analyzed every 10 to 15 environmental samples, one at the beginning and one at the end of each sample batch. These QC check samples consisted of the same compounds as those used in the daily calibration. Response factors for each compound were within 20 percent of the corresponding true value (relative to the calibration response factor). If the initial check sample failed this requirement, the problem would have been determined and resolved prior to proceeding with the sample analyses. If the end or final check sample failed, all of the environmental samples analyzed prior to the ending check sample would have been considered questionable and would not have been accepted.

3.5.2 Soil QA/QC

The QA/QC measures applied to the procedures associated with soil sampling and analysis during the OU-2 RI are described in the following subsections. These quality control checks were applied to the collection and analyses of soil samples obtained from soil borings, drill cuttings, and trench excavations.

3.5.2.1 Field QA/QC

Field quality control checks associated with the soil samples collected during the OU-2 investigation included duplicate samples and equipment blanks. Duplicate samples were collected at a minimum frequency of one for every twenty (or fewer) original samples as outlined in the QAPP (Ebasco, 1993e). Duplicates were collected from split-spoon samples during the drilling of soil borings and soil vapor well installations, and also from grab samples taken from drill cuttings or trench excavations. All duplicate samples were analyzed for the same chemical constituents as the corresponding sample from the same location.

Equipment blanks were collected to identify potential sample contamination associated with improper equipment decontamination, unclean bottles or containers, or improper shipping and transport procedures. They consisted of ASTM Type II organic-free water that was poured into or through decontaminated sampling equipment (split-spoon sampler and stainless steel sample sleeves) and collected in a sample container. During the OU-2 RI, equipment blanks were collected once a day (on those days when soil samples were taken) from each type of equipment used. All of the blanks were analyzed for the same chemical constituents as the actual field samples collected on that particular day.

3.5.2.2 Laboratory QA/QC

In addition to the field QA/QC procedures, the laboratory was required to perform a variety of quality control checks for every analytical run to ensure proper operating conditions for the instruments and accuracy of the sample results. The most important of these include method or reagent blanks, matrix spikes, and laboratory control samples. A brief description of these procedures is provided below.

A method or reagent blank consists of all the reagents (at their respective concentrations) used in the analytical procedure. These blanks are then treated and analyzed in the exact manner as the soil samples. If a contaminant detected in a soil sample is also present in the associated method blank, its presence in the soil sample can be attributed to laboratory contamination.

Matrix spikes are defined as the sample matrix (a JPL soil sample) spiked with method-specific target compounds to specific concentrations. Matrix spike samples (and matrix spike duplicates) are analyzed along with the soil samples. Based on the amount of each target compound recovered, conclusions can be drawn as to whether the soil matrix interferes with the analysis.

Laboratory control samples consist of deionized water spiked with method-specific target compounds to specific concentrations. These samples are analyzed along with the soil samples for each analytical run. This procedure is implemented to provide baseline performance data for the analysis and to verify the accuracy of the instrument.

3.5.3 Soil-Vapor QA/QC

Quality control measures associated with the soil vapor sampling procedures of the OU-2 RI are described in the following two subsections. These QA/QC checks were applied to the collection and analyses of soil-vapor samples from the nested soil-vapor wells.

3.5.3.1 Field QA/QC

Field quality control during the sampling of nested soil-vapor wells included the collection of duplicate soil-vapor samples and field blanks. Duplicates consisted of a second sample collected from a given sampling port within a soil-vapor well and were analyzed for the same constituents as the original sample to help assess the precision of the sampling and laboratory analytical procedures. Field blanks consisted of ambient or background air samples collected from within the mobile lab near the instrumentation. One field blank was collected at the beginning of each sampling day and analyzed for the same constituents as the environmental samples to determine potential influence of ambient conditions on the analytical results.

3.5.3.2 Mobile Laboratory QA/QC

All of the soil-vapor samples were analyzed on-site by TEG by the same analytical techniques and protocols applied to the soil vapor probe samples. As such, the laboratory QA/QC measures associated with the soil-vapor analyses are the same as those described above in Section 3.5.1.2.

3.5.4 Data Review and Evaluation

The analytical results of soil samples collected during the OU-2 RI were validated for those data that were used to determine the risk assessment and the nature and extent of the constituents of interest. The data were validated internally in accordance with the EPA National Functional Guidelines for Data Validation (February, 1988), and EPA Region IX specific data validation requirements. Details of the validation procedures that were applied to the OU-2 soil data are provided in Section 4.3.4.

Soil-vapor data were reviewed qualitatively for significant positive results to identify potential VOC source areas. Soil-vapor data are less quantitative than standard laboratory data derived from actual soil or groundwater samples and it is difficult to assess the effects of site variables on the detected concentrations. For the soil-vapor data, evaluations included a verification of standards for instrumental performance throughout the period of analysis and of the chromatographic profiles obtained during analysis. Analytical results of the soil-vapor samples

were used only as a guide for identifying additional sample locations to confirm potential contamination.

3.6 SOIL-VAPOR WELL, SOIL BORING, AND TEST PIT LOCATION SURVEY

Following each of the phased OU-2 RI field activities, an elevation and location survey was conducted for the completed soil borings, soil-vapor wells, and test pits. The elevation survey was required to establish a datum elevation for the subsurface explorations and the location survey was conducted to establish accurate reference points.

The surveys were conducted using a theodolite and electronic distance measuring device by R.Wada and Associates, a licensed surveyor located in Fullerton, California. Accuracy for horizontal and vertical control points was third order, and the precision of the elevation and distance measurements was to one-hundredth (0.01) of a foot. Horizontal control is in accordance with the Universal Transverse Mercator Coordinate System (North American Datum 83) for Zone 11 and reported in meters. Elevation control is based on the U.S. Coast and Geodetic Survey sea-level datum of 1929, through the medium of the Los Angeles County Engineer's precise level net, and reported in feet above mean sea level. The survey data are summarized in Table 3-8.

TABLE 3-1
RATIONALE FOR SOIL VAPOR AND SOIL SAMPLE LOCATIONS

Area Type	Potential Source Area	Relevant Information	Locations Sampled to Characterize Potential Sources
Buildings	Bldg. 306	Approximately 19,000 tons of soil contaminated with petroleum hydrocarbons removed from excavation for building's foundations and first floor.	SV-27, SV-28, SV-29, B-18
Discharge Points	DP-1	Reported to be from a large corrugated iron pipe located south of Building 103 (in the vicinity of the existing storm-drain outfall) and consisted of a yellow oily substance that was fairly clear and free of objectionable odor.	SV-58, B-23, B-23A, B-23B, TP-2, TP-2A
	DP-2	Located where a main north-south drainage through JPL entered the Arroyo near the southern extremities of the facility. Occurred near the southern tip of the former Southern California Edison substation. Evidence of previous discharge in the form of a channel blackened with a deposit of dark, odorless, pigment-like material. It was reported that considerable flow occurred at this location when combustion chambers were washed down.	B-29
	DP-3	Yellow-colored waste discharged into the Arroyo Seco from a JPL storm drain. The discharges originated as bleedoff, containing sodium chromate, from Cooling Tower No. 118 and emptied into the Arroyo from the storm-drain outfall located where the 48-inch-diameter outfall is presently situated south of the Southern California Edison substation.	TP-1, TP-1A
	DP-4	Reported to be from a 12-inch diameter drain that originates north of Building 103, passes under Building 103, and discharges at the Arroyo bank. Discharge consisted of a black, coal-tar-like substance with a strong objectionable odor that resembled petroleum derivatives. The discharge was in a small sump area and not of sufficient quantity to reach the streambed.	TP-3, TP-3A
Seepage Pits	1 and 2	Pits connected in tandem and located in area having oldest use-history on JPL site (former buildings 3, 4, 17, 19, and 22); recent discovery of solvent and other contaminants in nearby catch basin that was removed during construction work.	SV-19, SV-20, B-1, B-19
	3	Building 11 housed plumbing and electrical shops where solvents may have been used.	SV-43, B-2
	4	Pit connected in tandem with Seepage Pit No. 3. Seepage pit located under steep slope north of Building 11; inaccessible for soil vapor sampling van or drill rig, but accessible for manual soil vapor sampling.	SV-44
	5	Original use of Building 127 is not known; Building 68 once housed electrical and plumbing shops and Building 71 was used as "mechanical stores". Buildings were located near old solid propellant bunkers and may have been used to store solvents used in mixing and developing propellants.	SV-14, B-20, B-20A

TABLE 3-1
RATIONALE FOR SOIL VAPOR AND SOIL SAMPLE LOCATIONS

Area Type	Potential Source Area	Relevant Information	Locations Sampled to Characterize Potential Sources
Seepage Pits (cont.)	6	Drilling and sampling proposed because implications are similar to those for Seepage Pits 1, 3, and 5.	SV-13, B-6
	7, 7A, and 7B	Seepage pits connected in tandem; Building 107 housed machine shop fabrication shop, and metal pickling room; solvents used for cleaning and degreasing; alleged dumping of liquids in "drain hole" near southeast corner of building. Soils downgradient from seepage pits can be investigated with soil-vapor probes and a soil boring.	SV-52, SV-53, B-7
	8 (DW)	Dry well, now under Building 302, from pit where universal test machine was located; inaccessible to soil-vapor sampling, but two soil-vapor probes proposed along the southeast side of Building 302 and proposed downgradient monitoring well MW-12 is nearby.	SV-45, SV-46
	9	Pit is under Building's 302 shed area and true location is questionable. It may have been connected to former Building 13, which housed a small workshop, or the former Credit Union Building 44. Location inaccessible to soil vapor sampling van or drill rig, but accessible for manual soil vapor sampling and proposed downgradient monitoring well MW-12 is nearby.	SV-54
	10	Building 78 housed a hydraulic laboratory; solvents commonly used to clean machinery and degrease parts. Seepage pits located under retaining-wall foundation and bank of horizontally stacked tanks of nitrogen gas; inaccessible to soil vapor sampling van or drill rig, but accessible for manual soil vapor sampling.	SV-15
	11	At base of slope near retaining wall on north side of Building 113; inaccessible to soil vapor sampling van or drill rig, but small area at west end of building accessible for manual soil vapor sampling.	SV-55
	12	Chemistry test cell (liquid propellants) located in Building 74; solvents reportedly used for cleaning and degreasing; disposal of chemicals reported to have occurred by pouring into drains.	SV-16, B-22
	13 and 13A	Seepage pits, located under Building 302, from old materials laboratory (former Building 65); may have housed machinery and metals cleaned with solvents; also housed chemistry laboratory. Inaccessible to soil vapor van or drilling rig, but two soil-vapor probes sampled along southeast side of Building 302 and proposed downgradient monitoring well MW-12 is nearby.	SV-45, SV-46
	14	Shop for liquid propellant test cell (former Building 46); implications are same as those for Seepage Pit Nos. 12 and 15.	SV-23, B-21
	15	Shop building associated with old test cell Building 34 (Test Cell "F") and liquid testing facility; spilled solvents reportedly small, but did occur on a regular basis over several years.	SV-22, B-24

TABLE 3-1
RATIONALE FOR SOIL VAPOR AND SOIL SAMPLE LOCATIONS

Area Type	Potential Source Area	Relevant Information	Locations Sampled to Characterize Potential Sources
Seepage Pits (cont.)	16	Former Building 59 housed old paint shop.	SV-21, B-15
	17	Solid propellant mixing facility (former Building 55); solvents used to clean mixing hardware were disposed by pouring into sumps prior to installation of sanitary sewer system.	SV-41, B-11
	18 and 19	Shop for test cell No. 51 (solid propellant testing in Test Cell "X"); large test motors and hardware soaked in tubs of solvents (including carbon tetrachloride and acetone) that were not recycled and allegedly dumped into sumps on west side of Building 90 or at east end of solid propellant preparation area (east of Building 88).	SV-5, SV-10, SV-11, B-9
	20 and 21	Pits connected in tandem associated with former Building 63. Compressors and maintenance shop; solvents routinely used for parts cleaning. Soils downgradient from seepage pits could be sampled with single boring.	SV-40, B-16
	22	Wind tunnel building (former Building 30); no history of solvent or chemical usage.	No Sampling Conducted
	23 and 24	Seepage pits connected in tandem about 15 feet apart. Building 67's history is diverse. Although mainly an office building, several small laboratories (biology, kinetics, low-level radioactive, and spectroscopy) were located within structure over a several-year period—possibly before connections were made to sanitary sewer system. Since these pits are only about 15 feet apart, one soil vapor sampling probe and one soil boring well address both pits.	SV-37, B-19A
	25	Implications are same as those for Seepage Pit No. 23. Seepage pit located in walkway area between top of slope and south wall of Building 67; inaccessible to soil vapor sampling van or drill rig, but accessible for manual soil vapor sampling.	SV-39
	26	Structure housed experimental chemistry lab and fluorine propellant test cell with an acid-neutralizing pit constructed similar to a dry well, numerous chemicals reportedly disposed by dumping into available sumps near building. Seepage pit is upgradient from monitoring well MW-7.	SV-4
	27 (DW)	Dry well from sink at former soils test laboratory; no history of solvent or chemical usage in Building 246.	No Sampling Conducted
	28	"Acid Pit" for Building 77; now under Building 299; inaccessible to drill rig, but accessible for manual soil vapor sampling and possibly for mobile sampling van.	SV-38

TABLE 3-1
RATIONALE FOR SOIL VAPOR AND SOIL SAMPLE LOCATIONS

Area Type	Potential Source Area	Relevant Information	Locations Sampled to Characterize Potential Sources
Seepage Pits (cont.)	29	Test cell (former Building 32) used for liquid propellant testing since mid-1950s; solid propellants used during late 1940s. Seepage pit located near area where ongoing construction work disclosed solvent contamination in storm-drain catch basin and previously unknown seepage pit.	SV-17, B-4
	30	Building 117 housed former solid propellant test cell where solvents used to clean rocket motors and hardware; solvents reportedly not recycled and disposed of by dumping into nearby drains and sumps.	SV-50, B-10
	31	Buildings 107 and 112 contained propellant test cells; solid propellants may have been used during early history of building, along with solvents associated with solid propellant clean up. Building 107 combined with Building 112 and later converted to plasma flow research laboratory.	SV-31
	32	Seepage pit near east end of solid propellant preparation area and adjacent to Building 86; pits (sumps) in area reportedly used to dispose of solvents. Seepage pit located in small flat area between top of steep slope and south wall of Building 86; inaccessible to soil vapor sampling van or drill rig, but accessible for manual soil vapor sampling.	SV-9
	33	Development laboratory (Building 97) for solid propellant chemistry experimentation; solvents used to clean laboratory hardware; all sink drains led to seepage pit; a sump or dry well at west end of building reportedly used for solvent disposal.	SV-8, B-14
	34	Seepage pit at east end of solid propellant preparation area (Buildings 86, 87, 89, and 98); pit reportedly used for disposal of carbon tetrachloride, methyl ethyl ketone, trichloroethene, and other chemicals after sewer system installed.	SV-7, B-17
	35	Former Building 81 housed workshops, storage rooms, and offices. Seepage pit located in same area where solvents and other chemicals discovered in soil during ongoing construction. (See rationale for boring reference Seepage Pit Nos. 31 and 36.)	SV-35
	36	Storm drain catch basins removed during ongoing construction were contaminated with carbon tetrachloride, acetone, chloroform, trichloroethene, and mercury; sump tanks (leakage reported), dilution chambers, and seepage pits, associated with test cells and shops, existed along north side of former Jato Road.	SV-32, B-3
	37 (DW)	Dry well for drain from former Building 2 has unknown use, but implications are same as those for Seepage Pit Nos. 1, 2, 7A, 7B, 31, and 35.	SV-33, B-5

TABLE 3-1
RATIONALE FOR SOIL VAPOR AND SOIL SAMPLE LOCATIONS

Area Type	Potential Source Area	Relevant Information	Locations Sampled to Characterize Potential Sources
Waste Pits	WP-1	Erosion gully where solvents and mercury(?) reportedly dumped.	SV-58, B-23, B-23A, B-23B, TP-1, TP-1A
	WP-2	Shallow depression bulldozed in Arroyo Seco where glass and metal shavings were reportedly disposed.	SV-57, B-12
	WP-3	Solvents at varying concentrations reportedly dumped in hand-dug holes over a period of 2 to 3 years.	SV-1, SV-2, B-8
	WP-4 and WP-5	Two trenches identified by the EPA (1993) on an aerial photograph dated November 17, 1952, were designated as Annotations H and I (WP-4 and WP-5, respectively) during their aerial photograph analysis. It was suggested by the EPA that these two trenches, located in the southeast portion of the site adjacent to the Arroyo Seco, may represent waste-disposal activities. Both trenches were outside of the JPL boundary at the time the aerial photograph was taken and neither trench was part of JPL's operations. Therefore, historical information on their use or contents is not available. Based on the photograph and the locations of significant monuments, it is believed that all of WP-5 (Site I) and part of WP-4 (Site H) are covered by the parking lot along the southeast boundary of the JPL facility.	B-30, B-31

Notes:

- B - Soil boring/vapor well.
- DW - Dry well.
- SV - Soil-vapor probe.
- TP - Test pit.

TABLE 3-2

CROSS REFERENCE FOR POTENTIAL SOURCE LOCATIONS AND EXPLORATORY METHODS

Source-Point Designations		Soil-Vapor Probe Sample Numbers	Soil Boring/ Soil-Vapor Well Numbers	Test Pit Numbers	Source-Point Designations		Soil-Vapor Probe Sample Numbers	Soil Boring/ Soil-Vapor Well Numbers	Test Pit Numbers
Seepage Pits:	1	19	SB1*	na	Seepage Pits:	30	50	10	na
	2	20	1	na		31	31	SB19*	na
	3	43	2	na		32	9	--	na
	4	44	--	na		33	8	14	na
	5	14	20 & 20A	na		34	7	17	na
	6	13	6	na		35	35	SB21*	na
	7, 7A, & 7B	52 & 53D	7	na		36	32	3	na
	8	--	--	na		37	33	5	na
	9	54	--	na	Waste Pits:	WP-1	58	23B	na
	10	15	--	na		WP-2	57	12	na
	11	55 & 56D	--	na		WP-3	1 & 2	8	na
	12	16	22	na		WP-4	na	30	na
	13 & 13A	--	--	na		WP-5	na	31	na
	14	23 & 24D	21	na	Discharge Points:	DP-1	58	23B	TP-2 & 2A
	15	22	24	na		DP-2	na	29	na
	16	21	15	na		DP-3	na	--	TP-1 & 1A
	17	41 & 42D	11	na		DP-4	na	--	TP-3 & 3A
	18	11 & 12D	SB9*	na	Others:	Bldg 97	49	13	na
	19	5 & 6D	9	na		Bldg 302	45 & 46D	--	na
	20 & 21	40	16	na		Bldg 306	27, 28, 29, & 31	18	na
	23 & 24	37	19A	na					
	25	39	--	na					
	26	4	SB26*	na					
	28	38	--	na					
	29	17 & 18D	4	na					

- Notes:** 1) Soil vapor probe sample numbers with a "D" indicate a duplicate sample.
2) -- = Location not accessible for either probing or drilling.
3) *Soil borings completed during Pre-RI explorations.
4) na = Not Applicable.

TABLE 3-3
SOIL VAPOR PROBE DETAILS

Sample Number	Purpose	Date Probe Installed	Installation Method	Depth to Sampling Tip (ft bgs)	Location
SV-1	Soil-Vapor Probe	1/14/94	Direct Push	20	Waste Pit No. 3
SV-2	Soil-Vapor Probe	1/14/94	Direct Push	20	Waste Pit No. 3
SV-3	Soil-Vapor Probe	1/14/94	Direct Push	20	Non-Source Location Monitoring Well MW-16
SV-4	Soil-Vapor Probe	1/14/94	Direct Push	20	Seepage Pit No. 26
SV-5	Soil-Vapor Probe	1/14/94	Direct Push	22	Seepage Pit Nos. 18 and 19
SV-6(D)	Duplicate Sample	1/14/94	N/A	22	Seepage Pit Nos. 18 and 19
SV-7	Soil-Vapor Probe	1/15/94	Direct Push	12	Seepage Pit No. 34
SV-8	Soil-Vapor Probe	1/15/94	Direct Push	12	Seepage Pit No. 33
SV-9	Soil-Vapor Probe	1/15/94	Direct Push	19	Seepage Pit No. 32
SV-10	Soil-Vapor Probe	1/15/94	Direct Push	20	Seepage Pit Nos. 18 and 19
SV-11	Soil-Vapor Probe	1/15/94	Direct Push	20	Seepage Pit Nos. 18 and 19
SV-12(D)	Duplicate Sample	1/15/94	N/A	20	Seepage Pit Nos. 18 and 19
SV-13	Soil-Vapor Probe	1/15/94	Direct Push	20	Seepage Pit No. 6
SV-14	Soil-Vapor Probe	1/15/94	Direct Push	20	Seepage Pit No. 5
SV-15	Soil-Vapor Probe	1/15/94	Direct Push	20	Seepage Pit No. 10
SV-16	Soil-Vapor Probe	1/15/94	Direct Push	20	Seepage Pit No. 12
SV-17	Soil-Vapor Probe	1/15/94	Direct Push	11	Seepage Pit No. 29
SV-18(D)	Duplicate Sample	1/15/94	N/A	11	Seepage Pit No. 29
SV-19	Soil-Vapor Probe	1/15/94	Direct Push	19	Seepage Pit Nos. 1 and 2
SV-20	Soil-Vapor Probe	1/15/94	Direct Push	19	Seepage Pit Nos. 1 and 2
SV-21	Soil-Vapor Probe	1/16/94	Direct Push	10	Seepage Pit No. 16
SV-22	Soil-Vapor Probe	1/16/94	Direct Push	20	Seepage Pit No. 15
SV-23	Soil-Vapor Probe	1/16/94	Direct Push	20	Seepage Pit No. 14
SV-24(D)	Duplicate Sample	1/16/94	N/A	20	Seepage Pit No. 14
SV-25	Soil-Vapor Probe	1/16/94	Direct Push	20	Non-Source Location Monitoring Well MW-14
SV-26	Soil-Vapor Probe	1/16/94	Direct Push	14	Non-Source Location Monitoring Well MW-13
SV-27	Soil-Vapor Probe	1/16/94	Direct Push	16	Building 306
SV-28	Soil-Vapor Probe	1/16/94	Direct Push	9	Building 306
SV-29	Soil-Vapor Probe	1/16/94	Direct Push	13	Building 306
SV-30(D)	Duplicate Sample	1/16/94	N/A	13	Building 306
SV-31	Soil-Vapor Probe	1/16/94	Direct Push	13	Seepage Pit No. 31
SV-32	Soil-Vapor Probe	1/16/94	Direct Push	16	Seepage Pit No. 36
SV-33	Soil-Vapor Probe	1/16/94	Direct Push	11	Dry Well No. 37
SV-34	Soil-Vapor Probe	1/16/94	Direct Push	8	Non-Source Location Monitoring Well MW-15
SV-35	Soil-Vapor Probe	1/16/94	Direct Push	13	Seepage Pit No. 35
SV-36(D)	Duplicate Sample	1/16/94	N/A	13	Seepage Pit No. 35
SV-37	Soil-Vapor Probe	1/17/94	Direct Push	18	Seepage Pit Nos. 23 and 24
SV-38	Soil-Vapor Probe	1/17/94	Direct Push	12	Seepage Pit No. 28
SV-39	Soil-Vapor Probe	1/17/94	Direct Push	19	Seepage Pit No. 25
SV-40	Soil-Vapor Probe	1/17/94	Direct Push	19	Seepage Pit Nos. 20 and 21
SV-41	Soil-Vapor Probe	1/17/94	Direct Push	15	Seepage Pit No. 17
SV-42(D)	Duplicate Sample	1/17/94	N/A	15	Seepage Pit No. 17

TABLE 3-3
SOIL VAPOR PROBE DETAILS

Sample Number	Purpose	Date Probe Installed	Installation Method	Depth to Sampling Tip (ft bgs)	Location
SV-43	Soil-Vapor Probe	1/17/94	Direct Push	17	Seepage Pit No. 3
SV-44	Soil-Vapor Probe	1/17/94	Direct Push	11	Seepage Pit No. 4
SV-45	Soil-Vapor Probe	1/17/94	Direct Push	10	Dry Well No. 8 and Seepage Pit Nos. 13 and 13A
SV-46	Soil-Vapor Probe	1/17/94	Direct Push	20	Dry Well No. 8 and Seepage Pit Nos. 13 and 13A
SV-47	Soil-Vapor Probe	1/17/94	Direct Push	20	Non-Source Monitoring Well MW-12
SV-48(D)	Duplicate Sample	1/17/94	N/A	20	Non-Source Monitoring Well MW-12
SV-49	Soil-Vapor Probe	1/18/94	Direct Push	20	Building 197
SV-50	Soil-Vapor Probe	1/18/94	Direct Push	20	Seepage Pit No. 30
SV-51	Soil-Vapor Probe	1/18/94	Not Installed	Refusal @ 0.5	Seepage Pit Nos. 7, 7A, and 7B
SV-52	Soil-Vapor Probe	1/18/94	Direct Push	15	Seepage Pit Nos. 7, 7A, and 7B
SV-53	Soil-Vapor Probe	1/18/94	Direct Push	11	Seepage Pit Nos. 7, 7A, and 7B
SV-54	Soil-Vapor Probe	1/18/94	Direct Push	8	Seepage Pit No. 9
SV-55	Soil-Vapor Probe	1/18/94	Direct Push	6	Seepage Pit No. 11
SV-56(D)	Duplicate Sample	1/18/94	N/A	6	Seepage Pit No. 11
SV-57	Soil-Vapor Probe	1/18/94	Direct Push	17	Waste Pit No. 2
SV-58	Soil-Vapor Probe	1/18/94	Direct Push	6	Waste Pit No. 1

Notes:

bgs - Below ground surface.

(D) - Indicates duplicate sample obtained from the sample probe number listed above.

N/A - Not applicable.

SV - Soil vapor.

TABLE 3-4
SUMMARY OF ANALYTICAL METHODS
FOR ANALYSES PERFORMED ON SOIL-VAPOR SAMPLES

Parameter	Method	Detection Limits
Volatile Organic Compounds	8010/8020	
Benzene		1.0 µg/L
Vinyl chloride		1.0 µg/L
Carbon tetrachloride		1.0 µg/L
1,2-Dichloroethane		1.0 µg/L
Trichloroethene		1.0 µg/L
1,1-Dichloroethene		1.0 µg/L
1,1,1-Trichloroethane		1.0 µg/L
Bromomethane		1.0 µg/L
Chloroethane		1.0 µg/L
Chloroform		1.0 µg/L
trans-1,2-Dichloroethene		1.0 µg/L
cis-1,2-Dichloroethene		1.0 µg/L
Dichloromethane		1.0 µg/L
1,1-Dichloroethane		1.0 µg/L
Ethyl benzene		1.0 µg/L
1,1,2-Trichloroethane		1.0 µg/L
1,1,1,2-Tetrachloroethane		1.0 µg/L
1,1,2,2-Tetrachloroethane		1.0 µg/L
Tetrachloroethylene		1.0 µg/L
Toluene		1.0 µg/L
m,p-Xylenes		1.0 µg/L
o-Xylene		1.0 µg/L
Trichlorofluoromethane (Freon 11)		1.0 µg/L
Dichlorodifluoromethane (Freon 12)		1.0 µg/L
Trichlorotrifluoroethane (Freon 113)		1.0 µg/L

TABLE 3-5
SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
1	20	8/29/94	x	x						x	x	x		x	x	x	
1	37	8/29/94	x	x						x	x	x		x	x	x	
2	10	8/30/94	x	x						x	x	x		x	x	x	
2	38	8/30/94	x											x	x		
3	30	9/1/94	x	x						x	x	x		x	x	x	
3	50	9/1/94	x											x	x	x	
4	10	9/2/94	x	x						x	x	x		x	x	x	
4	20	9/2/94	x											x	x	x	
4	35	9/2/94	x	x						x	x	x		x	x	x	
4	40	9/2/94	x											x	x	x	
4	50	9/2/94	x	x						x	x	x		x	x	x	
4	61	9/2/94	x											x	x	x	
5	10	9/3/94	x	x						x	x	x		x	x	x	
6	10	9/4/94		x						x	x	x		x	x	x	
6	20	9/4/94	x											x	x	x	
6	30	9/4/94	x	x						x	x	x		x	x	x	
6	48.5	9/4/94	x											x	x	x	
6	51	9/4/94	x	x						x	x	x		x	x	x	
6	60.5	9/4/94	x											x	x	x	
6	70	9/4/94	x	x						x	x	x		x	x	x	
7	30	9/5/94	x	x						x	x	x		x	x	x	
7	50	9/5/94	x	x						x	x	x		x	x	x	
7	60	9/5/94	x											x	x	x	
8	10	9/8/94	x	x						x	x	x		x	x	x	
8	20	9/8/94	x											x	x	x	
8	30	9/8/94	x	x						x	x	x		x	x	x	
8	40	9/8/94	x											x	x	x	

TABLE 3-5

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
8	50	9/8/94	x	x						x	x	x		x	x	x	
8	65	9/8/94	x											x	x	x	
8	81	9/9/94	x	x						x	x	x		x	x	x	
8	101	9/9/94	x											x	x	x	
9	10	9/10/94	x											x	x		
9	21(DUP)	9/10/94	x	x						x	x	x		x	x	x	
9	21.5	9/10/94	x	x						x	x	x		x	x	x	
9	40.5	9/10/94	x											x	x		
9	48	9/10/94	x	x						x	x	x		x	x	x	
9	51	9/10/94	x											x	x		
9	60	9/10/94	x	x						x	x	x		x	x	x	
9	80	9/10/94	x											x	x	x	
10	11	9/12/94	x											x	x	x	
10	20.5(DUP)	9/12/94	x	x						x	x	x		x	x	x	
10	21	9/12/94	x	x						x	x	x		x	x	x	
10	31	9/12/94	x											x	x	x	
10	40.5	9/12/94	x	x						x	x	x		x	x	x	
10	50.5	9/12/94	x											x	x	x	
10	60.5	9/12/94	x	x						x	x	x		x	x	x	
10	70.5	9/12/94	x											x	x	x	
11	11	9/17/94	x											x	x	x	
11	21	9/17/94	x	x						x	x	x		x	x	x	
11	31	9/17/94	x											x	x	x	
11	40.5	9/17/94	x	x						x	x	x		x	x	x	
11	41	9/17/94	x											x	x	x	
11	51	9/17/94	x	x						x	x	x		x	x	x	
11	68.5	9/17/94	x											x	x	x	

TABLE 3-5
SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
11	71	9/17/94	x	x						x	x	x		x	x	x	
11	99.5	9/17/94	x											x	x	x	
12	10	9/19/94	x	x										x	x	x	
12	25.5	9/19/94	x	x						x	x	x		x	x	x	
12	34	9/19/94	x	x						x	x	x		x	x	x	
12	40.5	9/19/94	x											x	x	x	
12	60.5	9/19/94	x	x						x	x	x		x	x	x	
12	71	9/19/94	x											x	x	x	
13	10.5	9/20/94	x	x						x	x	x		x	x	x	
13	20.5	9/20/94	x											x	x	x	
13	30.5	9/20/94	x	x						x	x	x		x	x	x	
14	11	9/22/94	x	x						x	x	x		x	x	x	
15	11	9/24/94	x											x	x	x	
15	21	9/24/94	x	x						x	x	x		x	x	x	
15	31	9/24/94	x	x						x	x	x		x	x	x	
15	57	9/24/94	x											x	x	x	
15	61	9/24/94	x	x						x	x	x		x	x	x	
15	70	9/24/94	x											x	x	x	
15	81	9/24/94	x	x						x	x	x		x	x	x	
16	20.5(DUP)	9/28/94	x	x						x	x	x		x	x	x	
16	21	9/28/94	x	x						x	x	x		x	x	x	
16	31	9/28/94	x											x	x	x	
16	41	9/28/94	x	x						x	x	x		x	x	x	
16	50.5	9/28/94	x											x	x	x	
16	51	9/28/94	x											x	x	x	
16	61	9/28/94	x	x						x	x	x		x	x	x	
16	71	9/28/94	x											x	x	x	
16	81	9/28/94	x	x						x	x	x		x	x	x	
16	91	9/28/94	x											x	x	x	
16	101	9/28/94	x							x	x	x		x	x	x	

TABLE 3-5
SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
17	20.5	9/30/94	x											x	x	x	
17	26.5	9/30/94	x	x						x	x	x		x	x	x	
18	10	10/1/94	x	x						x	x	x		x	x	x	
18	34.5	10/1/94	x	x						x	x	x		x	x	x	
18	45	10/1/94	x											x	x	x	
18	50	10/1/94	x	x						x	x	x		x	x	x	
18	60	10/1/94	x											x	x	x	
18	70	10/1/94	x	x						x	x	x		x	x	x	
19	10.5	10/3/94	x	x						x	x	x		x	x	x	x
19	30.5	10/3/94	x	x						x	x	x		x	x	x	x
19A	20.5	10/4/94	x											x	x	x	
19A	40.5	10/4/94	x											x	x	x	
19A	51	10/4/94	x	x						x	x	x		x	x	x	x
19A	51(DUP)	10/4/94															x
19A	61	10/4/94	x											x	x	x	
19A	70.5	10/4/94	x	x						x	x	x		x	x	x	x
19A	90.5	10/4/94	x											x	x	x	
19A	100.5	10/4/94	x											x	x	x	
20	11	10/13/94	x											x	x	x	
20	21	10/13/94	x	x						x	x	x		x	x	x	
20	31	10/13/94	x	x						x	x	x		x	x	x	
20A	11	10/22/94	x											x	x	x	
20A	20.5(DUP)	10/22/94	x	x						x	x	x		x	x	x	
20A	21	10/22/94	x	x						x	x	x		x	x	x	
20A	50	10/22/94	x	x						x	x	x		x	x	x	
20A	71	10/22/94	x	x						x	x	x		x	x	x	
21	9	10/8/94	x											x	x	x	
21	19(DUP)	10/8/94	x	x						x	x	x		x	x	x	

TABLE 3-5
SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
21	19.5	10/8/94	x	x						x	x	x		x	x	x	
21	29	10/8/94	x											x	x	x	
21	49	10/9/94	x	x						x	x	x		x	x	x	
21	59	10/9/94	x	x						x	x	x		x	x	x	
22	11	10/11/94	x											x	x	x	
22	20.5(DUP)	10/11/94	x	x						x	x	x		x	x	x	
22	21	10/11/94	x	x						x	x	x		x	x	x	
22	31	10/11/94	x	x						x	x	x		x	x	x	
23	50.5	10/11/94	x	x						x	x	x		x	x	x	
23A	1.5	10/18/94	x	x						x	x	x		x	x	x	
23A	26	10/18/94	x	x						x	x	x		x	x	x	
24	10	10/15/94	x											x	x	x	
24	20	10/15/94	x	x						x	x			x	x	x	
24	29.5	10/15/94	x	x						x	x			x	x	x	
24	49.5	10/15/94	x	x						x	x			x	x	x	
24	59.5	10/15/94	x											x	x	x	
24	69.5	10/15/94	x	x						x	x	x		x	x	x	
29	4	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	7	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	10	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	15	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	20	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	20(DUP)	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	30	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	40	4/11/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	49	4/12/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	60	4/12/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	70	4/12/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	79.5	4/12/97	x	x		x	x	x	x	x	x	x	x	x	x	x	

TABLE 3-5
SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
30	5	4/1/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	10	4/1/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	15	4/1/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	20	4/1/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	30	4/1/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	40	4/2/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	50	4/2/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	60	4/2/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
30	69.5	4/2/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	5	4/8/97	x	x		x	x	x	x	x		x	x	x	x	x	
31	10	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	15	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	20	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	30	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	40	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	50	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	59.5	4/8/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
31	70	4/9/97	x	x		x	x	x	x	x	x	x	x	x	x	x	
BG-1	25	10/1/94	x														
BG-1A	20.5(DUP)	10/1/94	x											x	x		
BG-1A	21	10/1/94	x											x	x		
BG-2	18	10/1/94	x														
BG-2A	18	10/1/94	x											x	x		
TP-1	5	4/14/97	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-1	2	4/14/97	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-2	1	4/14/97	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-2	5	4/14/97	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-3	2	4/14/97	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-3	5	4/14/97	x	x	x	x	x	x	x		x	x	x	x	x	x	

TABLE 3-5
SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Analyses														Gross Alpha/ Gross Beta
			Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
TP-1A	2	6/10/99	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-1A	5	6/10/99	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-2A	1	6/10/99	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-2A	5	6/10/99	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-3A	2	6/10/99	x	x	x	x	x	x	x		x	x	x	x	x	x	
TP-3A	5	6/10/99	x	x	x	x	x	x	x		x	x	x	x	x	x	

Notes:

- BG - Background samples.
- DUP - Duplicate samples.
- PAHs - Polynuclear Aromatic Hydrocarbons.
- PCBs - Polychlorinated Biphenyls.
- SVOCs - Semi-Volatile Organic Compounds.
- TPH - Total Petroleum Hydrocarbons.
- TP - Test pit.
- VOCs - Volatile Organic Compounds.

TABLE 3-6
SUMMARY OF ANALYTICAL METHODS AND CONTAINERS
FOR ANALYSES PERFORMED ON SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Title 26 Metals + Strontium (Sr)	Various	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Variable	Variable*
Silver (Ag)	6010			6 months	
Arsenic (As)	206.2			6 months	
Barium (Ba)	6010			6 months	
Beryllium (Be)	6010			6 months	
Cadmium (Cd)	6010			6 months	
Chromium (Cr)	6010			6 months	
Cobalt (Co)	6010			6 months	
Copper (Cu)	6010			6 months	
Mercury (Hg)	245.1			28 days	
Molybdenum (Mo)	6010			6 months	
Nickel (Ni)	6010			6 months	
Lead (Pb)	239.2			6 months	
Antimony (Sb)	204.2			6 months	
Selenium (Se)	270.2			6 months	
Thallium (Tl)	279.2			6 months	
Vanadium (V)	6010			6 months	
Strontium (Sr)	6010			6 months	
Zinc (Zn)	6010			6 months	
Chromium (Hexavalent)	7196	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	24 hours	Variable*
Cyanide	335.3	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	14 days	Variable*
Tributyltin	GC/FPD	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	35 days	Variable*
Total Petroleum Hydrocarbons	EPA 418.1	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	28 days	Variable*
Semi-Volatile Organic Compounds	EPA 8270	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction within 14 days; Analysis within 40 days	Variable*
Phenol					
bis(2-chloroethyl)ether					
2-Chlorophenol					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Benzyl Alcohol					
1,2-Dichlorobenzene					
2-Methylphenol					
bis(2-chloroisopropyl)ether					
4-Methylphenol					
N-nitroso-di-n-dipropylamine					
Hexachloroethane					

TABLE 3-6

**SUMMARY OF ANALYTICAL METHODS AND CONTAINERS
FOR ANALYSES PERFORMED ON SOIL SAMPLES**

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Nitrobenzene					
Isophorone					
2-Nitrophenol					
2,4-Dimethylphenol					
Benzoic Acid					
bis(2-chloroethoxy)methane					
2,4-Dichlorophenol					
1,2,4-Trichlorobenzene					
Naphthalene					
4-Chloroaniline					
Hexachlorobutadiene					
4-Chloro-3-methylphenol					
2-Methylnaphthalene					
Hexachlorocyclopentadiene					
2,4,6-Trichlorophenol					
2,4,5-Trichlorophenol					
2-Chloronaphthalene					
2-Nitroaniline					
Dimethylphthalate					
Acenaphthylene					
2,6-Dinitrotoluene					
3-Nitroaniline					
Acenaphthene					
2,4-Dinitrophenol					
4-Nitrophenol					
Dibenzofuran					
2,4-Dinitrotoluene					
Diethylphthalate					
4-Chlorophenyl-phenyl ether					
Fluorene					
4-Nitroaniline					
4,6-Dinitro-2-methylphenol					
N-nitrosodiphenylamine					
4-Bromophenyl-phenylether					
Hexachlorobenzene					
Pentachlorophenol					
Phenanthrene					
Anthracene					
Di-n-butylphthalate					
Fluoranthene					
Pyrene					
Butylbenzylphthalate					
3,3-Dichlorobenzidine					
Benzo(a)anthracene					
Chrysene					
bis(2-ethylhexyl)phthalate					
Di-n-octylphthalate					
Benzo(b)fluoranthene					

TABLE 3-6
SUMMARY OF ANALYTICAL METHODS AND CONTAINERS
FOR ANALYSES PERFORMED ON SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Benzo(k)fluoranthene Benzo(a)pyrene Indeno(1,2,3-cd)pyrene Dibenzo(a,h)anthracene Benzo(g,h,i)perylene					
Nitrate	300.0	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	28 days	Variable*
Gross Alpha and Beta	900.0	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	6 months	Variable*
pH	150.1	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	ASAP	Variable*
Total Solids	160.3	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	7 days	Variable*
Dioxins 2,3,7,8 - TCDD 1,2,3,7,8 - Pe CDD 1,2,3,4,7,8 - Hx CDD 1,2,3,6,7,8 - Hx CDD 1,2,3,7,8,9 - Hx CDD 1,2,3,4,6,7,8 - Hp CDD 1,2,3,4,6,7,8,9 - OCDD	8280	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction within 14 days; Analysis within 40 days	Variable*
Furans 2,3,7,8 - TCDF 1,2,3,7,8 - Pe CDF 2,3,4,7,8 - Pe CDF 1,2,3,4,7,8 - Hx CDF 1,2,3,6,7,8 - Hx CDF 2,3,4,6,7,8 - Hx CDF 1,2,3,7,8,9 - Hx CDF 1,2,3,4,6,7,8 - Hp CDF 1,2,3,4,7,8,9 - Hp CDF 1,2,3,4,6,7,8,9 - OCDF	8280	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction within 14 days; Analysis within 40 days	Variable*

TABLE 3-6

**SUMMARY OF ANALYTICAL METHODS AND CONTAINERS
FOR ANALYSES PERFORMED ON SOIL SAMPLES**

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Polychlorinated Biphenyls	8081	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction within 14 days; Analysis within 40 days	Variable*
Arochlor - 1016					
Arochlor - 1221					
Arochlor - 1232					
Arochlor - 1242					
Arochlor - 1248					
Arochlor - 1254					
Arochlor - 1260					
Polynuclear Aromatic Hydrocarbons	8310	2.5" x 6" Stainless Steel (SS) Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction within 14 days; Analysis within 40 days	Variable*
Napthalene					
Acenaphthylene					
Acenaphthene					
Fluorene					
Phenanthrene					
Anthracene					
Fluoranthene					
Pyrene					
Chrysene					
Benzo(b)fluoranthene					
Benzo(k)fluoranthene					
Benzo(a)pyrene					
Dibenzo(a,h)anthracene					
Benzo(g,h,i)perylene					
Indeno(1,2,3-cd)pyrene					
Volatile Organic Compounds	EPA 8260	8 or 16 oz Glass Jar	Cool @ 4°C	14 days	Variable*
Chloromethane					
Bromomethane					
Vinyl chloride					
Chloroethane					
Methylene chloride					
Acetone					
Carbon disulfide					
1,1-Dichloroethene					
1,1-Dichloroethane					
1,2-Dichloroethane					
cis-1,2-Dichloroethene					
Chloroform					
2-Butanone (MEK)					
1,1,1-Trichloroethane					
Carbon tetrachloride					
Bromodichloromethane					

TABLE 3-6

**SUMMARY OF ANALYTICAL METHODS AND CONTAINERS
FOR ANALYSES PERFORMED ON SOIL SAMPLES**

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
1,2-Dichloropropane					
cis-1,3-Dichloropropene					
Trichloroethene					
Dibromochloromethane					
1,1,2-Trichloroethane					
Benzene					
trans-1,3-Dichloropropene					
Bromoform					
4-Methyl-2-Pentanone					
2-Hexanone					
Tetrachloroethene					
1,1,2,2-Tetrachloroethane					
Toluene					
Chlorobenzene					
Ethylbenzene					
Styrene					
Xylene (Total)					
Vinyl acetate					
Trichlorofluoromethane (Freon 11)					
1,1,2-Trichloro-1,2,2-Trifluoro- ethane (Freon 113)					
trans-1,2-Dichloroethene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
1,2-Dichlorobenzene					

Notes:

- * Method detection limits are highly matrix-dependent and are, therefore, variable. See Results tables in Section 4.0 for actual detection limits.

ASAP - As soon as possible upon delivery to laboratory.

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
1	Soil Boring	8/30/94	8/30/94	Percussion Hammer	38	10	1124.5	1114.5	Soil Boring Converted to Vapor Well
						21		1103.5	
						33		1091.5	
2	Soil Boring	8/30/94	8/30/94	Percussion Hammer	38.5	10	1126.2	1116.2	Soil Boring Converted to Vapor Well
						22		1104.2	
						37		1089.2	
3	Soil Boring	9/1/94	9/1/94	Percussion Hammer	52	16	1133.9	1117.9	Soil Boring Converted to Vapor Well
						29		1104.9	
						40		1093.9	
						47		1086.9	
4	Soil Boring	9/2/94	9/2/94	Percussion Hammer	60.5	11	1137.6	1126.6	Soil Boring Converted to Vapor Well
						20		1117.6	
						35		1102.6	
						56		1081.6	
5	Soil Boring	9/3/94	9/3/94	Percussion Hammer	12	2	1126.8	1124.8	Soil Boring Converted to Vapor Well
						5		1121.8	
						9		1117.8	
6	Soil Boring	9/6/94	9/6/94	Percussion Hammer	100.5	20	1137.5	1117.5	Soil Boring Converted to Vapor Well
						40		1097.5	
						60		1077.5	
						77		1060.5	
						96		1041.5	
7	Soil Boring	9/8/94	9/8/94	Percussion Hammer	60.5	20	1115.8	1095.8	Soil Boring Converted to Vapor Well
						35		1080.8	
8	Soil Boring	9/9/94	9/9/94	Percussion Hammer	101.5	20	1256.6	1236.6	Soil Boring Converted to Vapor Well
						30		1226.6	
						50		1206.6	
						70		1186.6	
						90		1166.6	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
9	Soil Boring	9/10/94	9/11/94	Percussion Hammer	90	20	1230.8	1210.8	Soil Boring Converted to Vapor Well
						35		1195.8	
						50		1180.8	
						70		1160.8	
						87		1143.8	
10	Soil Boring	9/13/94	9/13/94	Percussion Hammer	72	20	1232.8	1212.8	Soil Boring Converted to Vapor Well
						35		1197.8	
						50		1182.8	
						69		1163.8	
11	Soil Boring	9/17/94	9/18/94	Percussion Hammer	100	20	1193.1	1173.1	Soil Boring Converted to Vapor Well
						40		1153.1	
						60		1133.1	
						80		1113.1	
						96		1097.1	
12	Soil Boring	9/19/94	9/19/94	Percussion Hammer	81	20	1097.9	1077.9	Soil Boring Converted to Vapor Well
						40		1057.9	
						60		1037.9	
						76		1021.9	
13	Soil Boring	9/20/94	9/21/94	Percussion Hammer	48	10	1239.2	1229.2	Soil Boring Converted to Vapor Well
						20		1219.2	
						30		1209.2	
						40		1199.2	
14	Soil Boring	9/22/94	9/22/94	Percussion Hammer	18	5	1213.0	1208.0	Soil Boring Converted to Vapor Well
						10		1203.0	
						13		1200.0	
15	Soil Boring	9/24/94	9/24/94	Percussion Hammer	95	20	1123.5	1103.5	Soil Boring Converted to Vapor Well
						40		1083.5	
						60		1063.5	
						75		1048.5	
						90		1033.5	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
16	Soil Boring	9/29/94	9/29/94	Percussion Hammer	101.5	20	1199.2	1179.2	Soil Boring Converted to Vapor Well
						40		1159.2	
						60		1139.2	
						80		1119.2	
						95		1104.2	
17	Soil Boring	9/30/94	9/30/94	Percussion Hammer	40	12	1214.1	1202.1	Soil Boring Converted to Vapor Well
						24		1190.1	
						36		1178.1	
18	Soil Boring	10/2/94	10/2/94	Percussion Hammer	89.5	20	1109.4	1089.4	Soil Boring Converted to Vapor Well
						40		1069.4	
						55		1054.4	
						70		1039.4	
						85		1024.4	
19	Soil Boring	10/3/94	N/A	Percussion Hammer	46	N/A	1196.3	N/A	Soil Boring Only
19A	Soil Boring	10/4/94	10/4/94	Percussion Hammer	101	20	1196.4	1176.4	Soil Boring Converted to Vapor Well
						40		1156.4	
						60		1136.4	
						80		1116.4	
						96		1100.4	
20	Soil Boring	10/13/94	10/13/94	Percussion Hammer	41.5	10	1142.7	1132.7	Soil Boring Converted to Vapor Well
						20		1122.7	
						30		1112.7	
						37		1105.7	
20A	Soil Boring	10/23/94	10/23/94	Percussion Hammer	72	20	1142.7	1122.7	Soil Boring Converted to Vapor Well
						30		1112.7	
						47		1095.7	
						60		1082.7	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
21	Soil Boring	10/9/94	10/9/94	Percussion Hammer	90	20	1127.1	1107.1	Soil Boring Converted to Vapor Well
						40		1087.1	
						55		1072.1	
						70		1057.1	
						85		1042.1	
22	Soil Boring	10/12/94	10/12/94	Percussion Hammer	100.5	20	1129.0	1109.0	Soil Boring Converted to Vapor Well
						40		1089.0	
						60		1069.0	
						80		1049.0	
						95		1034.0	
23	Soil Boring	10/17/94	N/A	Percussion Hammer	20.5	N/A	1094.6	N/A	Soil Boring Only
23A	Soil Boring	10/18/94	N/A	Percussion Hammer	26.5	N/A	1094.8	N/A	Soil Boring Only
23B	Soil Boring	10/18/94	10/18/94	Percussion Hammer	21	5	1094.9	1089.9	Soil Boring Converted to Vapor Well
						11		1083.9	
						17		1077.9	
24	Soil Boring	10/15/94	10/16/94	Percussion Hammer	100	20	1125.0	1105.0	Soil Boring Converted to Vapor Well
						40		1085.0	
						60		1065.0	
						80		1045.0	
						95		1030.0	
25	Soil-Vapor Well	3/31/97	3/31/97	Sonic	202	20	1199.6	1179.6	Deep Soil-Vapor Well
						40		1159.6	
						60		1139.6	
						85		1114.6	
						100		1099.6	
						120		1079.6	
						145		1054.6	
						165		1034.6	
						180		1019.6	
						190		1009.6	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
26	Soil-Vapor Well	3/27/97	3/28/97	Sonic	206	20	1201.8	1181.8	Deep Soil-Vapor Well
						35		1166.8	
						55		1146.8	
						80		1121.8	
						100		1101.8	
						115		1086.8	
						140		1061.8	
						160		1041.8	
						180		1021.8	
						195		1006.8	
27	Soil-Vapor Well	3/18/97	3/18/97	Sonic	214	20	1214.2	1194.2	Deep Soil-Vapor Well
						35		1179.2	
						60		1154.2	
						85		1129.2	
						100		1114.2	
						120		1094.2	
						140		1074.2	
						160		1054.2	
						180		1034.2	
						205		1009.2	
28	Soil-Vapor Well	3/13/97	3/14/97	Sonic	179	20	1176.7	1156.7	Deep Soil-Vapor Well
						45		1131.7	
						65		1111.7	
						80		1096.7	
						105		1071.7	
						120		1056.7	
						140		1036.7	
						160		1016.7	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
29	Soil Boring	4/12/97	4/12/97	Sonic	83	20	1086.8	1066.8	Soil Boring Converted to Vapor Well
						35		1051.8	
						50		1036.8	
						60		1026.8	
						78		1008.8	
30	Soil Boring	4/2/97	4/2/97	Sonic	72	17	1088.9	1071.9	Soil Boring Converted to Vapor Well
						30		1058.9	
						40		1048.9	
						50		1038.9	
						65		1023.9	
31	Soil Boring	4/9/97	4/9/97	Sonic	73	20	1083.1	1063.1	Soil Boring Converted to Vapor Well
						35		1048.1	
						45		1038.1	
						55		1028.1	
						65		1018.1	
32	Soil-Vapor Well	3/29/98	3/29/98	Sonic	210	25	1206.6	1181.6	Deep Soil-Vapor Well
						40		1166.6	
						55		1151.6	
						70		1136.6	
						90		1116.6	
						115		1091.6	
						135		1071.6	
						155		1051.6	
						180		1026.6	
						195		1011.6	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
33	Soil-Vapor Well	3/31/98	4/1/98	Sonic	213	20	1214.0	1194.0	Deep Soil-Vapor Well
						40		1174.0	
						60		1154.0	
						85		1129.0	
						105		1109.0	
						120		1094.0	
						140		1074.0	
						160		1054.0	
						180		1034.0	
						200		1014.0	
34	Soil-Vapor Well	4/8/98	4/8/98	Sonic	135	20	1164.3	1144.3	Deep Soil-Vapor Well
						35		1129.3	
						50		1114.3	
						65		1099.3	
						80		1084.3	
						95		1069.3	
						108		1056.3	
						118		1046.3	
35	Soil-Vapor Well	4/14/98	4/14/98	Sonic	162.5	20	1183.2	1163.2	Deep Soil-Vapor Well
						35		1148.2	
						50		1133.2	
						60		1123.2	
						80		1103.2	
						95		1088.2	
						110		1073.2	
						125		1058.2	
						140		1043.2	
						155		1028.2	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
36	Soil-Vapor Well	3/27/98	3/27/98	Sonic	117	20	1232.8	1212.8	Deep Soil-Vapor Well
						35		1197.8	
						55		1177.8	
						75		1157.8	
						92		1140.8	
37	Soil-Vapor Well	4/7/98	4/7/98	Sonic	193	25	1195.7	1170.7	Deep Soil-Vapor Well
						40		1155.7	
						60		1135.7	
						80		1115.7	
						100		1095.7	
						120		1075.7	
						140		1055.7	
						155		1040.7	
38	Soil-Vapor Well	4/15/98	4/15/98	Sonic	178.5	25	1185.6	1160.6	Deep Soil-Vapor Well
						45		1140.6	
						65		1120.6	
						80		1105.6	
						95		1090.6	
						110		1075.6	
						125		1060.6	
						140		1045.6	
						155		1030.6	
						170		1015.6	

TABLE 3-7
DETAILS OF SOIL BORINGS, SOIL-VAPOR WELLS, AND TEST PITS

Boring/ Soil-Vapor Well/ Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
39	Soil-Vapor Well	4/17/98	4/17/98	Sonic	138	20	1144.1	1124.1	Deep Soil-Vapor Well
						35		1109.1	
						50		1094.1	
						70		1074.1	
						85		1059.1	
						100		1044.1	
						110		1034.1	
						120		1024.1	
						130		1014.1	
BG-1	Soil Boring	4/6/94	N/A	Hollow Stem Auger	25	N/A	1190.7	N/A	Soil Boring Only
BG-1A	Soil Boring	10/1/94	N/A	Hollow Stem Auger	21	N/A	1190.7	N/A	Soil Boring Only
BG-2	Soil Boring	4/6/94	N/A	Hollow Stem Auger	18	N/A	1265.2	N/A	Soil Boring Only
BG-2A	Soil Boring	10/1/94	N/A	Hollow Stem Auger	18	N/A	1265.2	N/A	Soil Boring Only
TP-1	Test Pit	4/14/97	N/A	Backhoe	6	N/A	1097.2	N/A	Trenches Completed near Surface Drainage Outfalls
TP-2	Test Pit	4/14/97	N/A	Backhoe	5	N/A	1094.4	N/A	Trenches Completed near Surface Drainage Outfalls
TP-3	Test Pit	4/14/97	N/A	Backhoe	5	N/A	1058.5	N/A	Trenches Completed near Surface Drainage Outfalls
TP-1A	Test Pit	6/10/99	N/A	Backhoe	6	N/A	1097.0	N/A	Trenches Completed near Surface Drainage Outfalls
TP-2A	Test Pit	6/10/99	N/A	Backhoe	6	N/A	1094.4	N/A	Trenches Completed near Surface Drainage Outfalls
TP-3A	Test Pit	6/10/99	N/A	Backhoe	6	N/A	1058.3	N/A	Trenches Completed near Surface Drainage Outfalls

Notes:

amsl - Above mean sea level.
BG - Background samples.
bgs - Below ground surface.
N/A - Not applicable.
TP - Test pit.

TABLE 3-8

**SUMMARY OF ELEVATION AND LOCATION DATA FOR SOIL BORINGS,
SOIL-VAPOR WELLS, AND TEST PITS**

Boring/ Soil-Vapor Well/ Test Pit Number	Universal Transverse Mercator Coordinates (NAD 83) (Coordinates in meters)		Elevation of Ground Surface (ft amsl)
	Northing	Easting	
1	3,785,201.50	392,427.18	1124.54
2	3,785,195.21	392,414.19	1126.15
3	3,785,255.54	392,455.30	1133.87
4	3,785,211.20	392,371.64	1137.55
5	3,785,238.24	392,451.67	1126.77
6	3,785,102.33	392,340.03	1137.53
7	3,785,076.69	392,388.48	1115.78
8	3,785,219.01	391,956.41	1256.58
9	3,785,245.01	392,158.36	1230.82
10	3,785,252.44	392,149.08	1232.78
11	3,785,185.31	392,215.78	1193.07
12	3,784,960.76	392,306.23	1097.89
13	3,785,266.94	392,190.22	1239.24
14	3,785,238.68	392,252.98	1212.98
15	3,785,038.70	392,233.85	1123.45
16	3,785,152.96	392,104.38	1199.18
17	3,785,221.93	392,326.53	1214.06
18	3,784,838.60	392,059.94	1109.37
19	3,785,108.39	391,898.78	1196.27
19A	3,785,108.12	391,896.41	1196.35
20	3,785,148.50	392,351.22	1142.68
20A	3,785,151.27	392,357.48	1142.65
21	3,785,059.58	392,281.44	1127.13
22	3,785,084.74	392,278.29	1129.04
23B	3,785,052.58	392,402.25	1094.86
24	3,785,037.02	392,245.07	1125.01
25	3,785,152.81	392,102.71	1199.56
26	3,785,150.18	392,058.11	1201.82
27	3,785,149.53	392,114.77	1214.23
28	3,785,135.94	392,138.78	1176.69
29	3,784,860.60	392,154.69	1086.78
30	3,784,873.06	392,233.80	1088.92
31	3,784,808.60	392,175.03	1083.12
32	3,785,198.84	392,225.28	1206.62
33	3,785,192.34	392,010.65	1214.03

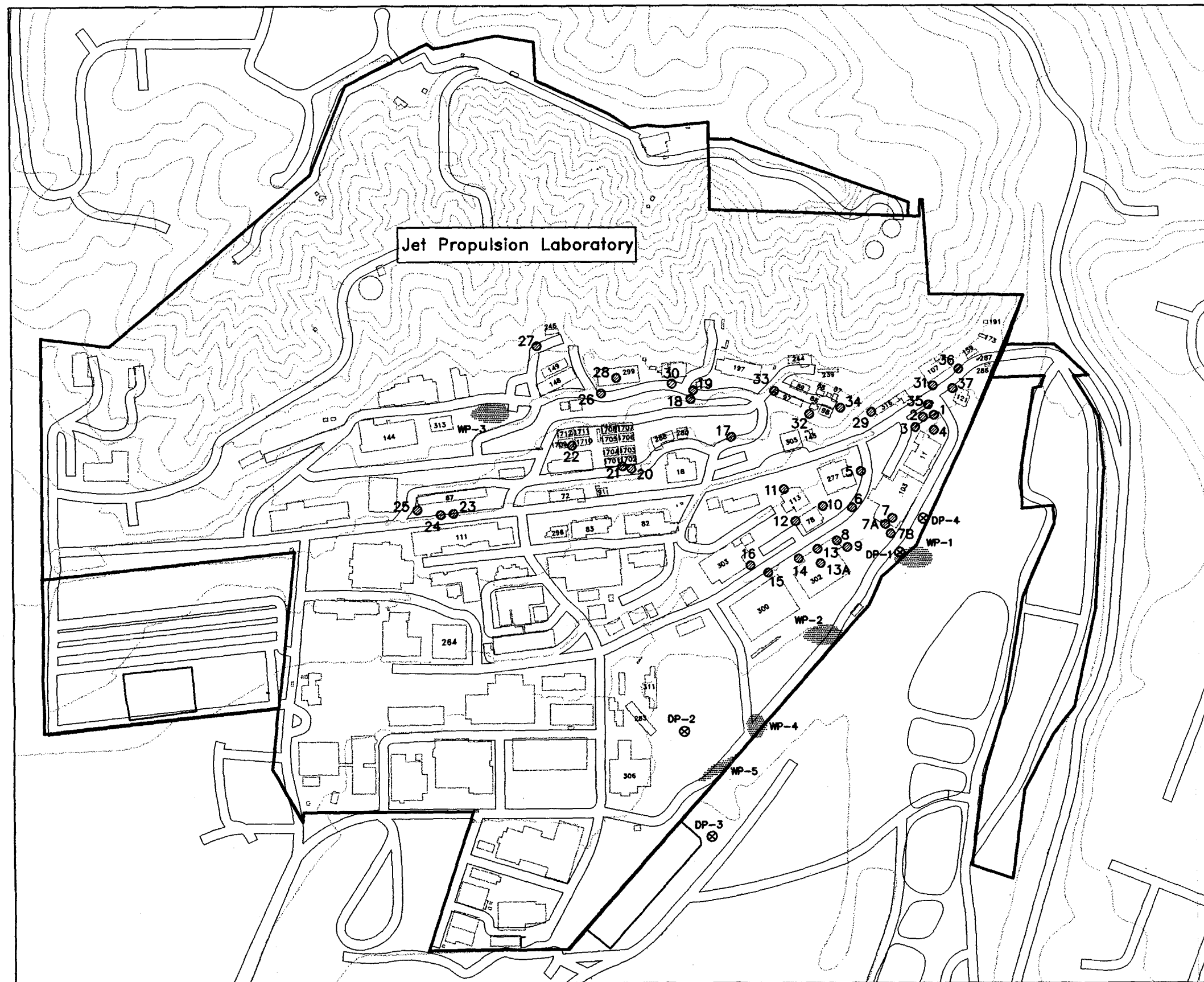
TABLE 3-8

**SUMMARY OF ELEVATION AND LOCATION DATA FOR SOIL BORINGS,
SOIL-VAPOR WELLS, AND TEST PITS**

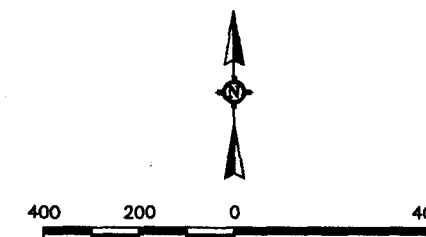
Boring/ Soil-Vapor Well/ Test Pit Number	Universal Transverse Mercator Coordinates (NAD 83) (Coordinates in meters)		Elevation of Ground Surface (ft amsl)
	Northing	Easting	
34	3,785,071.55	392,120.74	1164.26
35	3,785,081.01	392,002.21	1183.15
36	3,785,182.60	391,896.56	1232.80
37	3,785,112.31	391,927.59	1195.69
38	3,785,049.37	391,873.76	1185.63
39	3,784,933.86	391,897.05	1144.09
BG-1	3,785,027.48	391,516.73	1190.67
BG-2	3,785,133.15	391,630.81	1265.22
TP-1	3,785,083.01	392,415.88	1097.17
TP-2	3,785,056.02	392,405.53	1094.40
TP-3	3,784,728.54	392,180.13	1058.45
TP-1A	3,784,728	392,178	1097.0
TP-2A	3,785,057	392,404	1094.4
TP-3A	3,785,085	392,416	1058.3

Notes:

amsl - Above mean sea level.
 BG - Background samples.
 TP - Test pit.



① Seepage Pit or Dry Well Location and Number
 ⊗ DP-1 Surface Water Discharge Points to the Arroyo Seco
 WP-1 Suspected Waste Disposal Area



**Source: USGS, 7.5 Minute Topographic Map
Pasadena, CA 1966, Revised 1988, 1994.**

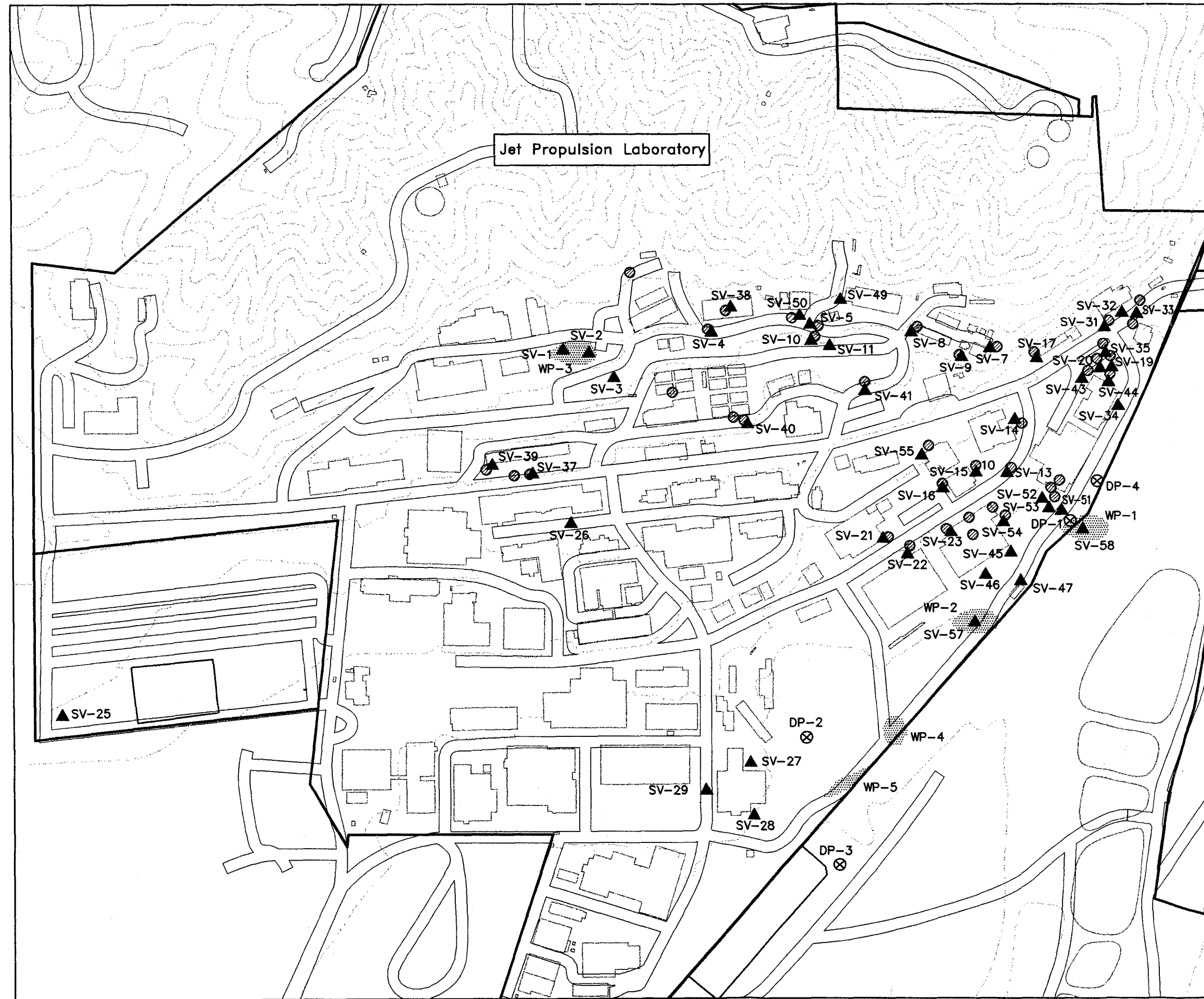
FIGURE 3-1

LOCATIONS OF KNOWN SEEPAGE PITS/
DRY WELLS, DISCHARGE POINTS
AND SUSPECTED WASTE AREAS

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Explanation

- ▲ SV-58 Soil Vapor Probe Sample Location Completed During RI Investigation
- ⊙ Seepage Pit or Dry Well Location
- ⊗ DP-1 Surface Water Discharge Points to the Arroyo Seco
- WP-1 Suspected Waste Disposal Area



300 150 0 300

SCALE IN FEET

Source: USGS, 7.5 Minute Topographic Map
Pasadena, CA 1966, Revised 1988, 1994.

Soil Vapor Probe Completion Dates

SV-1 to SV-5	1/14/94
SV-6 to SV-20	1/15/94
SV-21 to SV-35	1/16/94
SV-37 to SV-47	1/17/94
SV-49 to SV-58	1/18/94

See Table 3-2 for details.

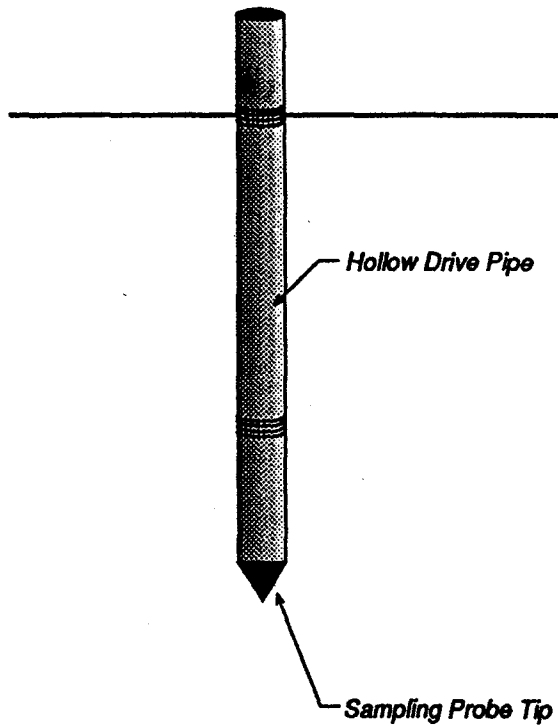
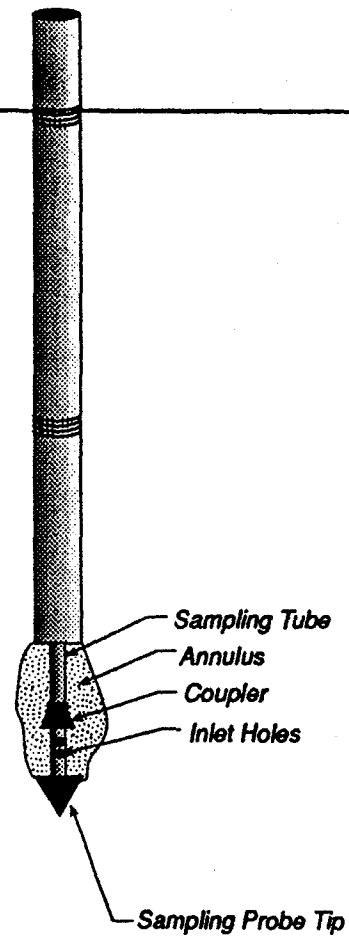
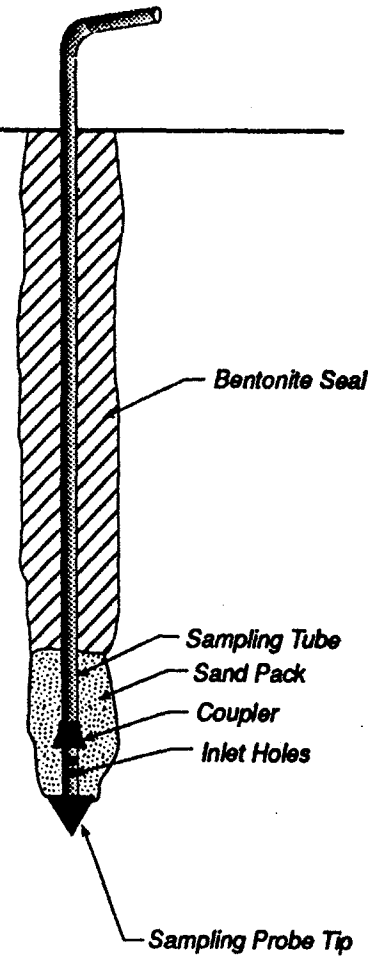
FIGURE 3-2

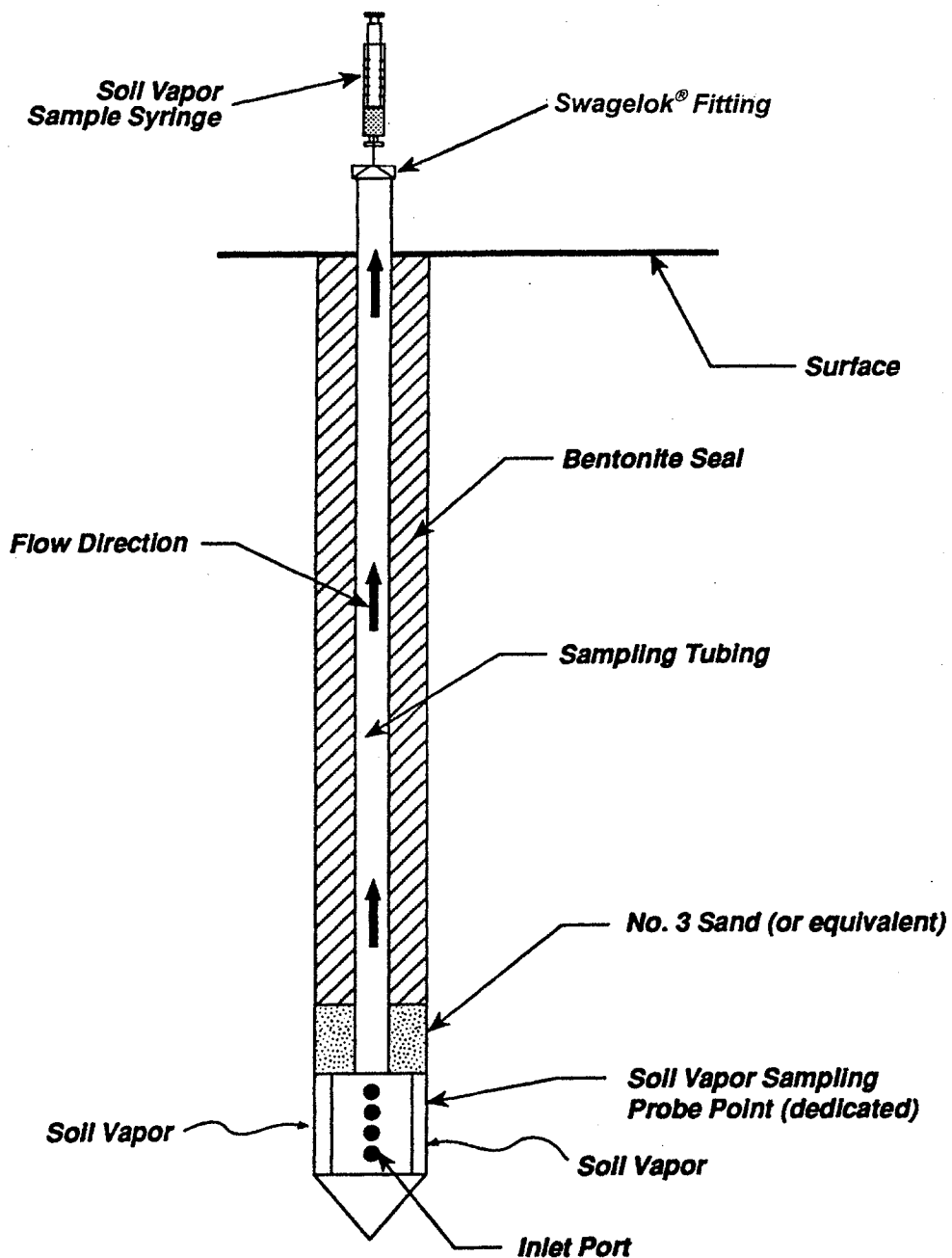
LOCATIONS OF SOIL VAPOR PROBES WITH
ASSOCIATED SEEPAGE PITS/DRY WELLS,
DISCHARGE POINTS AND SUSPECTED WASTE AREAS

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Step 1**Installation of Soil-Vapor Probe****Step 2****Removal of Hollow Drive Pipe****Step 3****Construction of Soil-Vapor Probe***Not to Scale***FIGURE 3-3****TYPICAL SCHEMATIC OF A
SOIL VAPOR PROBE INSTALLATION**Jet Propulsion Laboratory
Pasadena, California**FOSTER WHEELER ENVIRONMENTAL
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Not to Scale

FIGURE 3-4

**TYPICAL SCHEMATIC OF A
SOIL VAPOR PROBE SAMPLING SETUP**

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Unified Soil Classification System				CONSISTENCY CLASSIFICATION							
				Granular Soil							
MAJOR DIVISIONS			USCS SYMBOL	DESCRIPTION	Density	Abbr.	Blows/ft	Bedrock	Abbr.		
Coarse-Grained Soils More than half of the material is larger than the No. 200 Sieve Size	Gravels More than half of coarse fraction is larger than No. 4 Sieve Size	Clean Gravels (little or no fines)	GW	Well-graded gravels or gravel/sand mixtures, little or no fines, (Wide range of grain sizes and substantial amounts of all intermediate particle sizes)	Very Loose	VL	0 to 4	Very Soft	VS		
			GP	Poorly-graded gravels or gravel/sand mixtures, little or no fines, (Predominantly one size or range of sizes with some intermediate particle sizes missing)	Loose	L	5 to 10	Soft	SO		
		Gravels with Fines (appreciable amount of fines)	GM	Silty gravels, gravel/sand/clay mixtures	Medium Dense	MD	11 to 30	Moderately Hard	MH		
			GC	Clayey gravels, gravel/sand/clay mixtures	Dense	D	31 to 50	Hard	H		
	Sands More than half of coarse fraction is smaller than No. 4 Sieve Size <small>(For Visual classification, the 0.25-inch size may be used as equivalent to the No. 4 Sieve Size)</small>	Clean Sands (little or no fines)	SW	Well-graded sands or gravelly sands, little or no fines, (Wide range of grain sizes and substantial amounts of all intermediate particle sizes)	Very Dense	VD	Over 50	Very Hard	VH		
			SP	Poorly-graded sands or gravelly sands, little or no fines, (Predominantly one size or range of sizes with some intermediate particle sizes missing)	Cohesive Soils						
		Sands with Fines (appreciable amount of fines)	SM	Silty sands, sand/silt mixtures	Consistency	Abbr.	Field Identification				
					Very Soft	VS	Easily penetrated several inches by fist				
					Soft	SO	Easily penetrated several inches by thumb				
					Medium Stiff	MS	Can be penetrated several inches by thumb/moderate effort				
Fine-Grained Soils More than half of the material is smaller than the No. 200 Sieve Size <small>The No. 200 Sieve Size is about the smallest particle size visible to the naked eye</small>	Silt and Clays	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Stiff	ST	Readily indented by thumb/penetrated only with great effort					
				Very Stiff	VS	Readily indented by thumbnail					
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Hard	H	Indented with difficulty by thumbnail					
				Soil Odor						Soil Color	
		Odor	Abbr.	Color	Abbr.	Condition	Abbr.				
		OL	Organic silts and organic silt/clays of low plasticity	None	N	Light Brown	LB	Dry	DR		
				Light Hydrocarbon	LH	Yellow Brown	YB	Slightly Moist	SM		
		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Mod. Hydrocarbon	MH	Brown	B	Moist	MO		
				Strong Hydrocarbon	SH	Dark Brown	DB	Wet	WT		
		CH	Inorganic clays of high plasticity, fat clays	Alcohol	A	Grayish Brown	GB	Saturated	ST		
Humus	H			Reddish Brown	RB						
OH	Organic clays of medium to high plasticity	Musty	M	Dark Red	DR						
		Foul	F	Grayish Red	GR						
Highly Organic Soils	Pt	Peat and other highly organic soils. (Readily identified by color, odor, spongy feel, and frequently by fibrous texture)	Diesel	D	Red	R					
			Gasoline	G	Yellowish Red	YR					
			Sulfur	S	White	W					
			Turpentine	T	Light Gray	LG					
					Gray	G					
					Dark Gray	DG					
					Yellow	Y					
					Pale Yellow	PY					
					Grayish Yellow	GY					
					Black	B					
					Tan	T					
					Light Red	LR					
				Reference: Modified after the Unified Soil Classification System, Corps of Engineers, US Army Technical Memorandum No. 3-357, Volume 1, March, 1953 (Revised April, 1960)							

Particle		Size				Limits	
Silt or Clay	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		
	No. 200 Sieve	No. 40 Sieve	No. 10 Sieve	No. 4 Sieve	0.75 inches	3 inches	12 inches
U.S. Standard Sieve Size							

FIGURE 3-5

UNIFIED SOIL CLASSIFICATION
SYSTEM SCHEMATIC FOR SOILS DESCRIPTION

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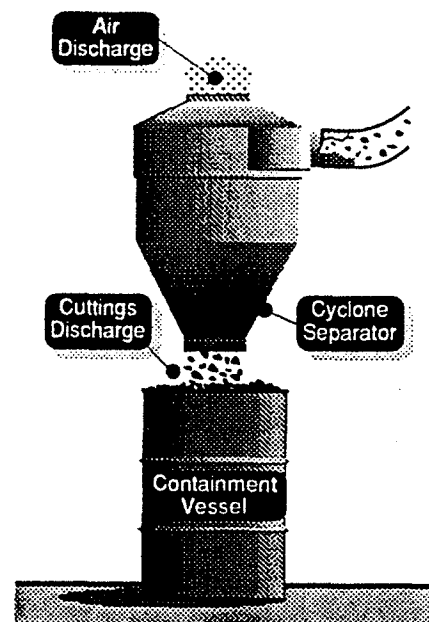
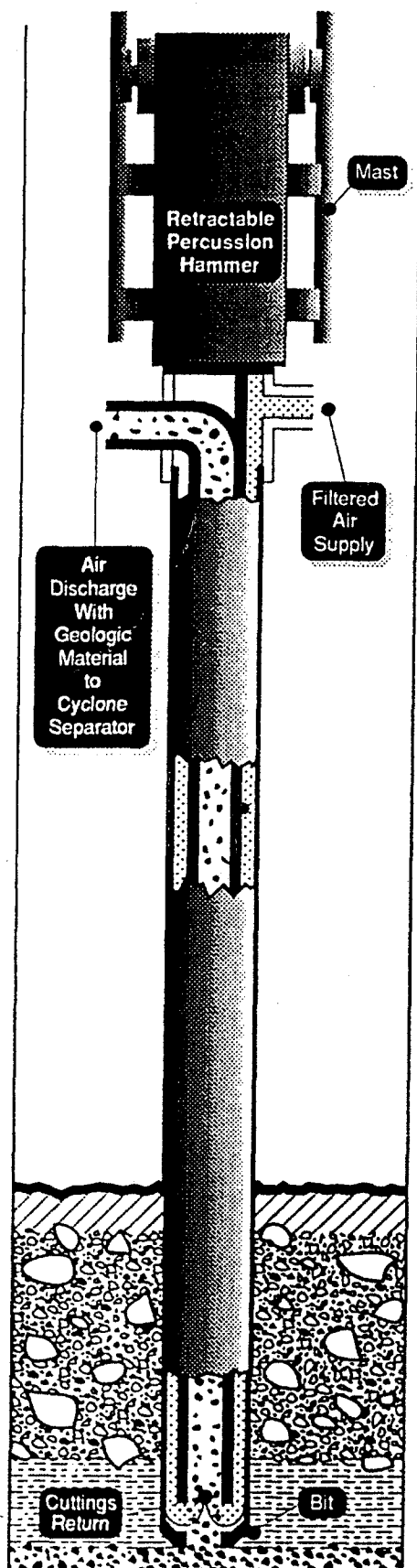


FIGURE 3-6

TYPICAL SCHEMATIC OF DUAL WALL PERCUSSION HAMMER DRILLING METHOD

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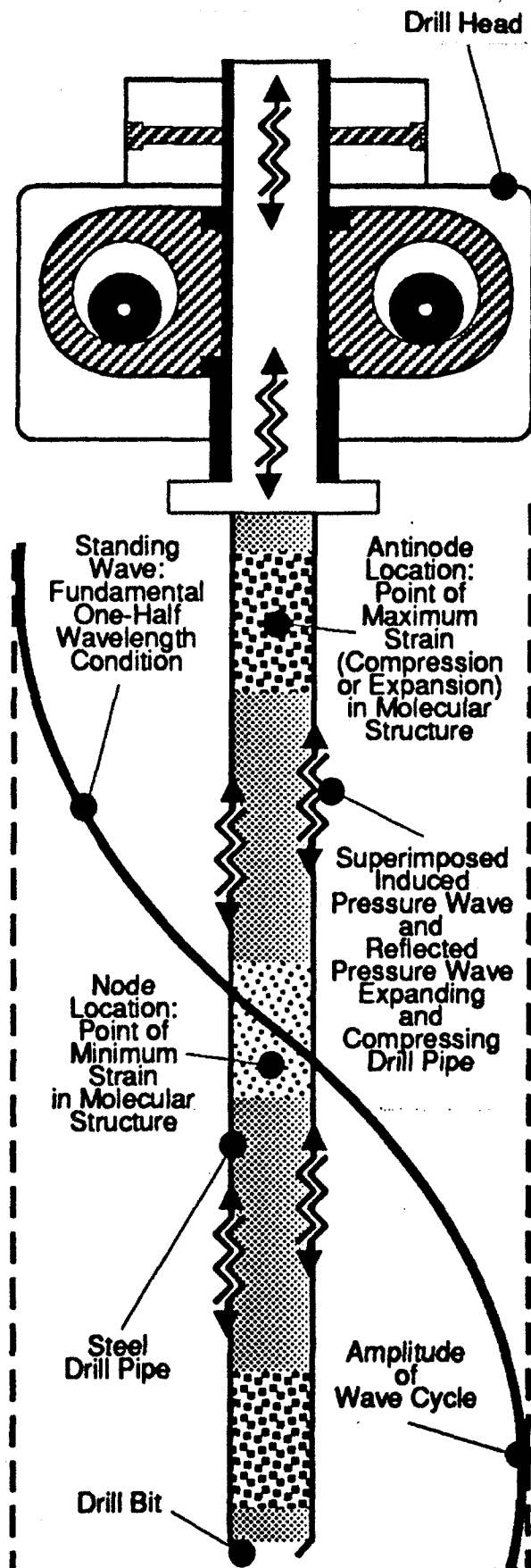


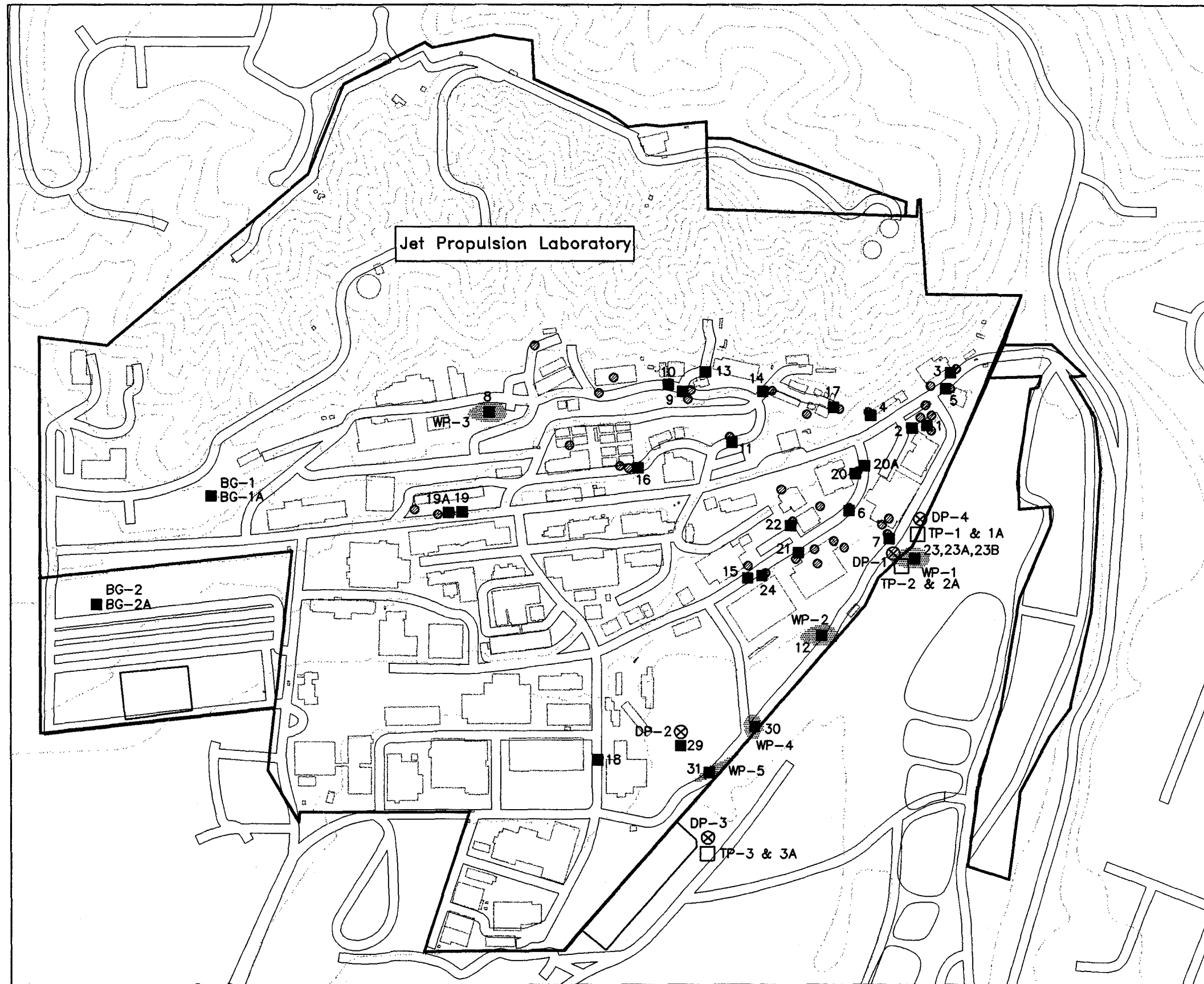
FIGURE 3-7

TYPICAL SCHEMATIC OF SONIC DRILLING METHOD

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Explanation

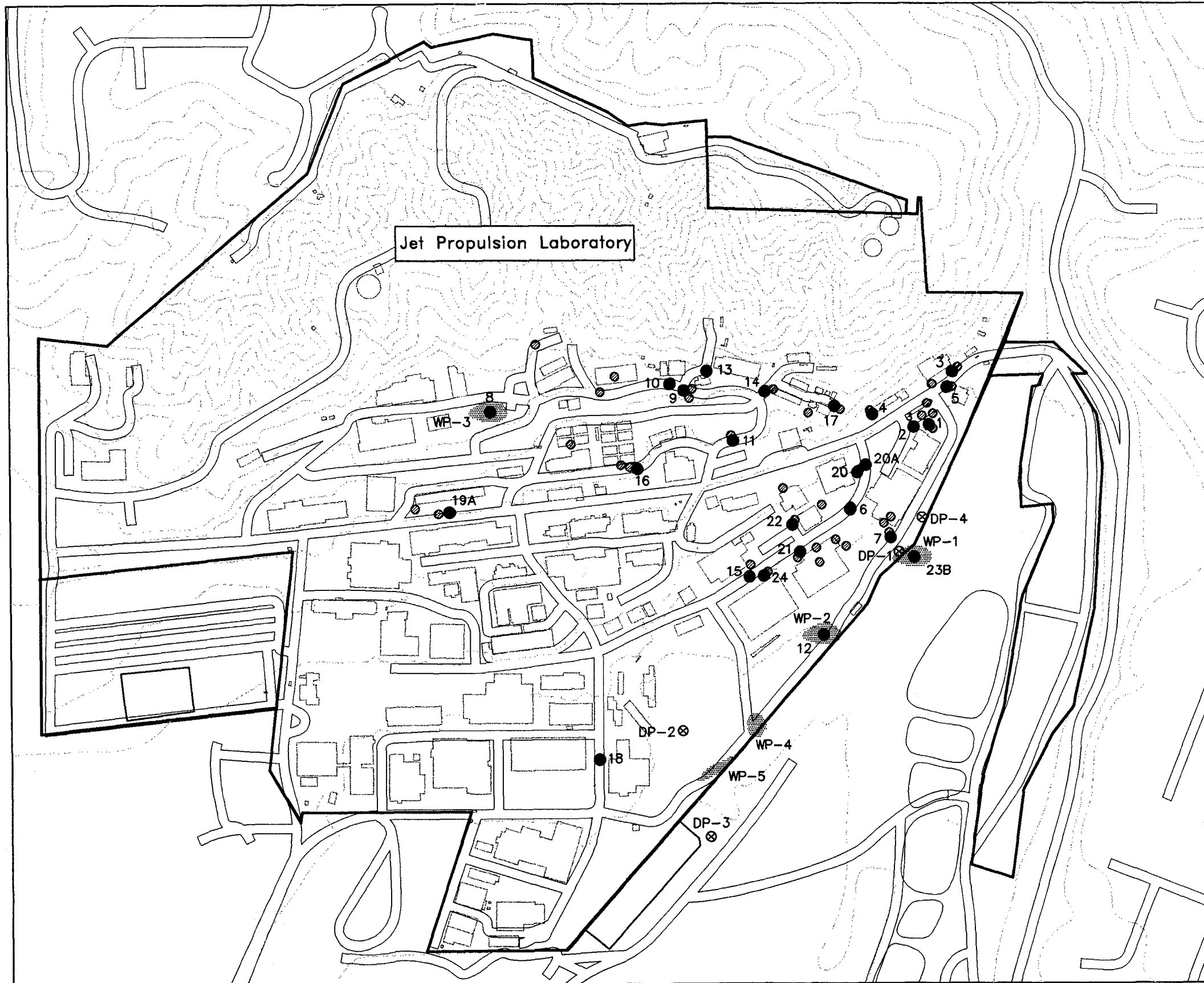
- 24 Soil Boring Drilled During RI Investigation
- TP-1 Test Pit Completed During RI Investigation
- ⊙ Seepage Pit or Dry Well Location
- ⊗ DP-1 Surface Water Discharge Points to the Arroyo Seco
- WP-1 Suspected Waste Disposal Area

400 200 0 400
 SCALE IN FEET
 Source: USGS, 7.5 Minute Topographic Map Pasadena, CA 1966, Revised 1986, 1994.

**Completion Dates for
Soil Borings and Test Pits**


BG-1	-	4/6/94	17	-	9/30/94
BG-1A	-	10/1/94	18	-	10/2/94
BG-2	-	4/6/94	19	-	10/3/94
BG-2A	-	10/1/94	19A	-	10/4/94
1	-	8/30/94	20	-	10/13/94
2	-	8/30/94	20A	-	10/23/94
3	-	9/1/94	21	-	10/9/94
4	-	9/2/94	22	-	10/12/94
5	-	9/3/94	23	-	10/17/94
6	-	9/6/94	23A	-	10/18/94
7	-	9/8/94	23B	-	10/18/94
8	-	9/9/94	24	-	10/15/94
9	-	9/10/94	29	-	4/12/97
10	-	9/13/94	30	-	4/2/97
11	-	9/17/94	31	-	4/9/97
12	-	9/19/94	TP-1	-	4/14/97
13	-	9/20/94	TP-1A	-	6/10/99
14	-	9/22/94	TP-2	-	4/14/97
15	-	9/24/94	TP-2A	-	6/10/97
16	-	9/29/94	TP-3	-	4/14/97
			TP-3A	-	6/10/99

FIGURE 3-8
**LOCATIONS OF SOIL BORINGS AND TEST PITS
 W/ASSOCIATED SEEPAGE PITS/DRY WELLS,
 DISCHARGE POINTS AND SUSPECTED WASTE AREAS**
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Explanation

- 24 Soil Vapor Well Converted From Soil Boring During RI Investigation (Drilling Round No. 1)
- ⊙ Seepage Pit or Dry Well Location
- ⊗ DP-1 Surface Water Discharge Points to the Arroyo Seco
- WP-1 Suspected Waste Disposal Area


 400 200 0 400
 SCALE IN FEET
 Source: USGS, 7.5 Minute Topographic Map
 Pasadena, CA 1966, Revised 1988, 1994.

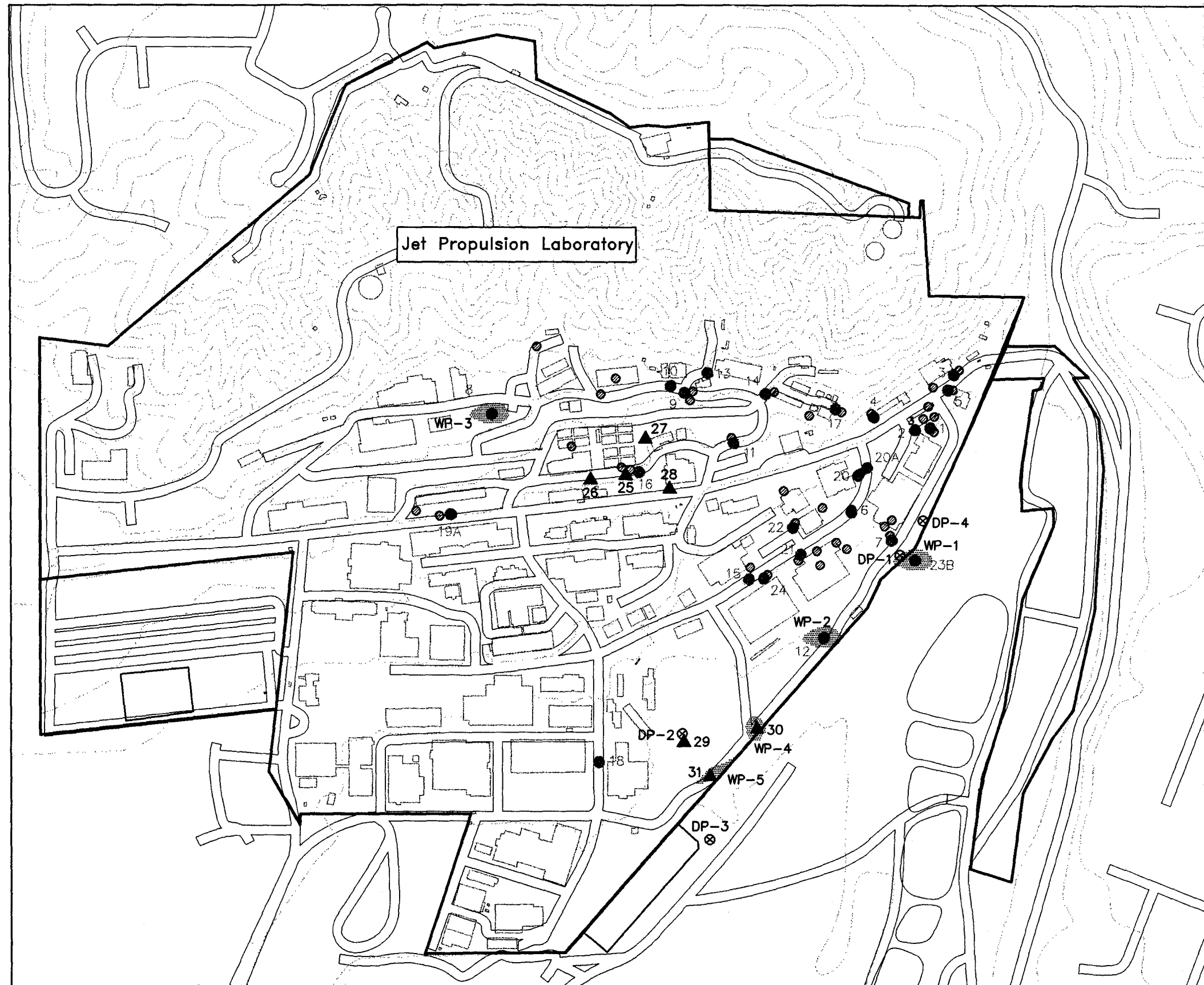
**Completion Dates for
Soil Vapor Well Nos. 1 through 24**

1	-	8/30/94
2	-	8/30/94
3	-	9/1/94
4	-	9/2/94
5	-	9/3/94
6	-	9/6/94
7	-	9/8/94
8	-	9/9/94
9	-	9/11/94
10	-	9/13/94
11	-	9/18/94
12	-	9/19/94
13	-	9/21/94
14	-	9/22/94
15	-	9/24/94
16	-	9/29/94
17	-	9/30/94
18	-	10/2/94
19A	-	10/4/94
20	-	10/13/94
20A	-	10/23/94
21	-	10/9/94
22	-	10/22/94
23B	-	10/18/94
24	-	10/16/94

FIGURE 3-9
**LOCATIONS OF SOIL VAPOR WELL NOS. 1 THRU 24
 WITH ASSOCIATED SEEPAGE PITS/DRY WELLS,
 DISCHARGE POINTS AND SUSPECTED WASTE AREAS**

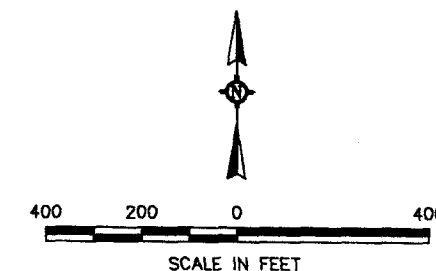
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Explanation

- ▲ 31 Soil Vapor Well Installed During Current Vapor Well Installation (Drilling Round No. 2)
- 24 Soil Vapor Well Installed Prior to Current Soil Vapor Well Installation
- ⊙ Seepage Pit or Dry Well Location
- ⊗ DP-1 Surface Water Discharge Points to the Arroyo Seco
- WP-1 Suspected Waste Disposal Area



Source: USGS, 7.5 Minute Topographic Map
Pasadena, CA 1966, Revised 1988, 1994.

Completion Dates for Soil Vapor Well Nos. 25 through 31

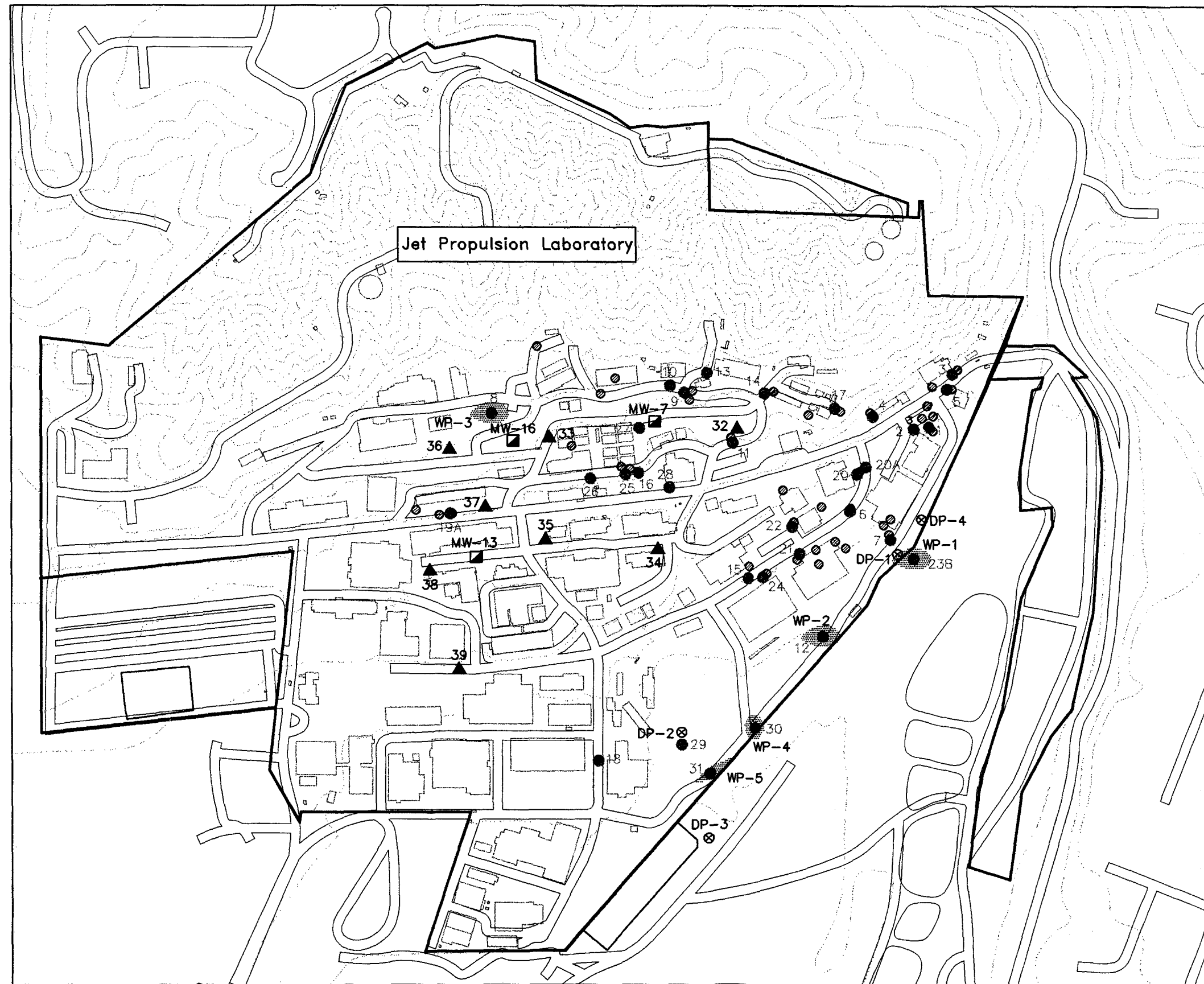
25	-	3/31/97
26	-	3/28/97
27	-	3/18/97
28	-	3/14/97
29	-	4/12/97
30	-	4/2/97
31	-	4/9/97

FIGURE 3-10


LOCATIONS OF SOIL VAPOR WELL NOS. 25 THRU 31
WITH ASSOCIATED SEEPAGE PITS/DRY WELLS,
DISCHARGE POINTS AND SUSPECTED WASTE AREAS


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Explanation	
▲ 39	Soil Vapor Well Installed During Current Vapor Well Installation (Drilling Round No. 3)
● 31	Soil Vapor Well Installed Prior to Current Soil Vapor Well Installation
MW-16	Groundwater Monitoring Well
⊙	Seepage Pit or Dry Well Location
⊗ DP-1	Surface Water Discharge Points to the Arroyo Seco
WP-1	Suspected Waste Disposal Area





SCALE IN FEET

Source: USGS, 7.5 Minute Topographic Map
Pasadena, CA 1966, Revised 1988, 1994.

Completion Dates for
Soil Vapor Well Nos. 32 through 39

32	-	3/29/98
33	-	4/1/98
34	-	4/8/98
35	-	4/14/98
36	-	3/27/98
37	-	4/7/98
38	-	4/15/98
39	-	4/17/98

FIGURE 3-11
LOCATIONS OF SOIL VAPOR WELL NOS. 32 THRU 39
WITH ASSOCIATED SEEPAGE PITS/DRY WELLS,
DISCHARGE POINTS AND SUSPECTED WASTE AREAS

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FIGURE 3-12	
TYPICAL SCHEMATIC OF A SOIL VAPOR WELL CONSTRUCTION DIAGRAM	
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4.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination in the soil and soil vapor beneath JPL (OU-2) is summarized in this section. On-site and off-site groundwater contamination was characterized in the remedial investigation (RI) report for OU-1 and OU-3 (FWENC, 1999). For the OU-2 RI, two sources of data were used in defining the nature and extent of contamination as follows:

- Analyses conducted on soil samples collected during the drilling of selected soil borings and test pits
- An initial soil-vapor survey using single point soil-vapor probes and soil vapor sampling events where vapor samples were collected from multi-port soil-vapor wells.

In this section, each of these data sources is considered separately.

4.1 OU-2 RI SAMPLING PROGRAM

Previous investigations have suggested that past disposal of chemical wastes occurred on-site in the northeast portion of JPL. These previous investigations, to a large extent, provided information in developing the rationale for sampling during the OU-2 RI. The following discussion summarizes the selection of sample locations, the types and frequency of chemical data collected, and the rationale for the sampling.

4.1.1 Sampling Locations

Various "seepage pits" and other waste disposal areas were identified as possible locations of past chemical waste disposal during previous investigations (see Sections 1.3.3 and 3.1). The locations of the seepage pits and other potential waste disposal areas are shown in Figure 4-1. Using the information from these prior investigations, an initial screening event was conducted in January 1994, consisting of soil-vapor probes installed at depths ranging from 6 to 20 feet (one depth per probe). Soil borings (most of which were subsequently converted to soil-vapor wells) were also drilled and sampled to characterize any contaminants that might be identified at potential source areas. Subsequent soil-vapor analyses were performed on samples collected from the soil-vapor wells to characterize the horizontal and vertical extent of soil-vapor contamination. Three test pits, located adjacent to surface water discharge points, were excavated and sampled in areas where surface contamination was suspected.

A summary of the details of all sampling points, including initial soil-vapor probes, soil borings, soil-vapor wells, and test pits completed during the OU-2 RI is presented in Table 4-1. Locations of the vapor probes are shown in Figure 4-2, and the soil boring and test pit locations are shown in Figure 4-3. Locations of the soil borings converted to soil-vapor wells are shown in Figure 4-4.

4.1.2 Data Types

Two types of data were collected during the RI including (1) soil-vapor data obtained from analysis of vapor drawn from the soil pore space, and (2) data obtained from direct analyses of soil samples. In this report, the terms "soil analysis" and "soil data" will refer to the direct analysis of collected soil samples. A summary of the installation/drilling rounds, and types of data ultimately collected from each probe, soil boring, or vapor well is presented below:

Installation/ Drilling Round	Date	Soil-Vapor Probes, Borings/Wells, and Test Pits	Soil-Vapor Wells Converted from Soil Borings	Data Collected
SV Probe Installation	January 1994	SV-1 through SV-58	N/A	Soil Vapor
First Drilling Round	August-October 1994	Nos. 1 through 24 (BG-1, BG-1A, BG-2, and BG-2A)*	Nos. 1 through 24, (except Nos. 19, 23, and 23A)	Soil (All) Soil Vapor (except Nos. 19, 23, 23A)
Second Drilling Round	March-April 1997	Nos. 25 through 31 TP-1, TP-2, and TP-3	Nos. 25 through 31	Soil Nos. 29 through 31 TP-1, TP-2 and TP-3 Soil Vapor Nos. 25 through 31 only
Third Drilling Round	March-April 1998	Nos. 32 through 39	Nos. 32 through 39	Soil Vapor
Reexcavation of Test Pits	June 1999	TP-1A, TP-2A, and TP-3A	N/A	Soil

Notes:

* Background analyses for metals.

BG - Background samples.

SV - Soil-vapor probes.

TP - Test pits.

N/A - Not applicable.

For the first two drilling rounds (see table above), the soil data were obtained from samples collected during the drilling of the soil borings and the soil-vapor data were collected through subsequent sampling of the same boreholes following their conversion to soil-vapor wells (see Table 4-1). No soil sampling for chemical analysis was conducted during the third drilling round.

4.1.3 Sampling Events and Analyses Conducted

A total of seven soil vapor sampling events (including the initial soil-vapor survey) were conducted. Soil sampling was conducted in conjunction with two of these events. As mentioned above, the soil samples were collected during the first and second drilling rounds, and,

subsequently, through reexcavation of the test pits (see table above). The soil vapor sampling events are summarized in Table 4-2, and soil sample analyses in Table 4-3. All of the soil-vapor samples were analyzed for volatile organic compounds (VOCs) only. The soil samples were analyzed for various parameters as outlined in Table 4-3. Analytes reported for the analytical methods are listed in Table 4-4. Individual sampling events, including sampling locations and all analyses performed are discussed in detail below.

4.1.3.1 Soil Vapor Sampling Events

All soil-vapor samples collected during sampling event Nos. 1 through 7 were analyzed for VOCs using EPA Method 8010/8020 (for the list of compounds analyzed using EPA Method 8010/8020, refer to Table 4-4). Analyses of all samples were conducted on-site in a mobile analytical laboratory.

Event 1 (Soil Vapor Probes SV-1 through SV-58)

At the beginning of the OU-2 RI (January, 1994), a total of 48 soil-vapor probes were installed at depths ranging from 6 to 20 feet to conduct an initial screening investigation (see Section 3.2). One vapor probe (SV-51) met refusal and could not be sampled. The soil-vapor probes were positioned based on findings from the previous investigations (see Sections 1.33 and 3.1), during which various potential waste-disposal locations were identified. Locations of the soil-vapor probes are shown in Figure 4-2. Analytical (laboratory) data for Event 1 are presented in Appendix B.

Event 2 (Soil Vapor Well Nos. 1 through 24)

Based on the results of the initial screening investigation, 25 soil borings (Nos. 1 through 24 including 20A) were drilled and converted to multi-port soil-vapor wells in a preliminary effort to assess the vertical distribution of VOC vapors in the subsurface soils. Soil borings Nos. 19, 23, and 23A were not converted to soil-vapor wells. This drilling was conducted from August through October of 1994. The locations of the soil-vapor wells are shown in Figure 4-4. Soil samples were not analyzed for VOCs pursuant to a mandate from the RWQCB that such data would not be acceptable for defining the nature and extent of potential contamination in JPL soils. Each vapor well was constructed with sampling tips placed at various depths (refer to Table 4-1), and the wells were first sampled in December 1994. This sampling and analysis constitutes Event 2. Analytical (laboratory) data for Event 2 are presented in Appendix C1.

Event 3 (Soil Vapor Well Nos. 1 through 24)

Vapor samples from soil vapor well Nos. 1 through 24 were again collected and analyzed for VOCs in March 1995 to confirm the VOC levels observed in Event 2. This 1995 sampling and analysis constitutes Event 3, after which soil vapor well Nos. 1 through 24 were not subsequently sampled. Analytical (laboratory) data for Event 3 are presented in Appendix C2.

Event 4 (Soil Vapor Well Nos. 25 through 31)

Following Events 2 and 3, seven additional soil-vapor wells (Nos. 25 through 31) were installed in March and April of 1997. Soil samples were collected from three of the boreholes (Nos. 28, 29, and 30) for chemical analysis prior to conversion to soil-vapor wells. Locations of these soil-vapor wells are shown in Figure 4-4. Deep soil vapor well Nos. 25 through 28 were installed to further characterize the vertical extent of VOC vapors near the vapor well (No. 16) with the highest total soil vapor concentrations from Events 2 and 3. Soil-vapor wells Nos. 29 through 31 were installed to characterize two potential waste-disposal areas (WP-4 and WP-5) and a discharge point (DP-2) identified after the completion of soil-vapor Events 2 and 3. Vapor samples from these wells were collected in June 1997 and analyzed for VOCs. This sampling constitutes Event 4. Analytical (laboratory) data for Event 4 are presented in Appendix C3.

Event 5 (Soil Vapor Well Nos. 25 through 31)

Vapor samples from soil vapor well Nos. 25 through 31 were again collected and analyzed for VOCs in July 1997 to confirm the VOC levels observed in Event 4. This sampling constitutes Event 5, after which soil-vapor well Nos. 29 through 31 were not subsequently sampled. Analytical (laboratory) data for Event 5 are presented in Appendix C4.

Event 6 (Soil Vapor Well Nos. 25 through 28 and Nos. 32 through 39)

A third drilling round, during which eight additional multi-port soil-vapor wells (Nos. 32 through 39) were installed in March and April of 1998. These soil-vapor wells were installed at the locations shown in Figure 4-4. Locations of soil vapor well Nos. 32 through 39 were selected to further delineate the area, or areas, within the JPL facility with the highest VOC concentrations based on soil-vapor sampling from Events 2 through 5 and the VOC concentrations found in groundwater from monitoring wells MW-7, MW-13, and MW-16.

Vapor samples from these new deep soil-vapor wells were collected in May 1998 and analyzed for VOCs. In addition, vapor samples from existing soil vapor well Nos. 25 through 28 were also analyzed for VOCs. This sampling constitutes Event 6. Analytical (laboratory) data for Event 6 are presented in Appendix C5.

Event 7 (Soil Vapor Well Nos. 32 through 39)

Vapor samples were collected from multiple depths in soil vapor well Nos. 32 through 39 and analyzed for VOCs in June 1998 to confirm the VOC levels observed in these wells in Event 6. This constitutes Event 7, the final soil vapor sampling event for the OU-2 RI. A monitoring program is now in place that calls for quarterly sampling and VOC analysis of soil vapor from soil vapor well Nos. 25 through 28 and Nos. 32 through 39. Analytical (laboratory) data for Event 7 are presented in Appendix C6.

4.1.3.2 Soil Samples

During the first drilling round (August-October, 1994), soil samples were collected from soil boring Nos. 1 through 24 at various depths. Four additional borings, BG-1, BG-1A, BG-2, and BG-2A (shown in Figure 4-3) were drilled and sampled to obtain background concentrations of metals. All soil samples, except for those from soil borings BG-1 and BG-2, were shipped to Analytical Technologies, Inc. (ATI) for chemical analyses that included Title 26 Metals plus strontium and hexavalent chromium, semi-volatile organic compounds (SVOCs), cyanide, nitrate, total petroleum hydrocarbons, pH, gross alpha and beta (radioactivity), and total solids as listed in Table 4-3. Analytical data for soil samples analyzed by ATI are presented in Appendix D1. Soil samples from soil borings BG-1 and BG-2 were analyzed for Title 26 Metals plus strontium, VOCs, and SVOCs by Montgomery Laboratories.

During the second drilling round (March-April, 1997) soil samples were collected from borings B-29, B-30, and B-31 at various depths. In addition, three test pits (TP-1, TP-2, and TP-3) were excavated with a backhoe in areas of suspected waste disposal. Soil samples from the boreholes and test pits were sent to Intertek Testing Services (ITS) for the analyses identified in the above paragraph (except radioactivity) as well as polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), dioxins and furans, and tributyltin. Samples from the three test pits were also analyzed for VOCs. Analytical data for soil samples submitted to ITS are presented in Appendix D2. As noted above (Section 4.1.2), the test pits (TP-1, TP-2, and TP-3) were reexcavated in June 1999 (designated as TP-1A, TP-2A, and TP-3A) and samples were collected and sent to Quanterra Incorporated for the same suite of analyses specified for samples collected during the second drilling round as described above (including VOCs). Analytical data for soil samples submitted to Quanterra Incorporated are presented in Appendix D3.

4.2 SOIL-VAPOR SAMPLE RESULTS

Provided in this section are summaries and evaluation of the chemical data pertaining to the nature and extent of VOC vapors detected in soil-vapor samples collected during Events 1 through 7. Analytical (laboratory) data from these RI sampling events are included in Appendix B (Event 1) and Appendix C (Events 2 through 7).

Soil-vapor samples were collected at 48 soil-vapor probe locations and from 40 multi-port soil-vapor wells during Events 1 through 7 (refer to Tables 4-1 and 4-2). Through the course of the RI field program and associated soil-vapor and soil-data evaluations, it became apparent that VOC vapors are the primary constituents impacting on-site soils at JPL. A summary of the soil vapor sampling events and the supporting rationale for each event is presented in the table below.

Soil-Vapor Event	Wells/Probes	Date Sampled	Rationale
1	SV-1 through SV-58 (Sample numbers)	January 1994	Initial vapor-probe screening to evaluate horizontal extent of possible contamination at identified potential source areas (Sample numbers include duplicates).
2	Nos. 1 through 24	December 1994	Further screening to assess the possibility of contamination at identified potential source locations.
3	Nos. 1 through 24	May 1995	Confirmation of results from Event 2.
4	Nos. 25 through 31	June 1997	Initial assessment of lateral and vertical extent of high VOC concentrations associated with well No. 16 (Nos. 25 through 28); assessment of suspected waste discharge point (No. 29); assessment of waste disposal areas WP-4 and WP-5 (Nos. 30 and 31, respectively).
5	Nos. 25 through 31	July 1997	Confirmation of results from Event 4.
6	Nos. 25 through 28; Nos. 32 through 39	May 1998	Further assessment of vertical and horizontal extent of high VOC concentrations associated with vapor well No. 16 and in groundwater from monitoring wells MW-7, MW-13, and MW-16.
7	Nos. 32 through 39	June 1998	Confirmation of results from Event 6.

The soil-vapor data from the seven OU-2 RI vapor-sampling events were used to develop VOC “envelope” maps to illustrate the lateral extent of VOC vapors in the subsurface soils. For these maps, all soil-vapor wells in which VOCs were detected at any depth are included in the envelope (either for total VOCs or for a specific VOC). Wells from which any sample contained VOC concentrations in excess of 100 µg/L-vapor were defined as “hot spots” and were designated as such on the maps using cross-hatching. These envelope maps were supplemented with additional schematic cross-sectional diagrams and traditional horizontally scaled cross sections (which include VOC concentrations) to illustrate the vertical distribution of VOC vapors. The schematic cross-sectional diagrams were prepared for Events 2 and 3 and Events 6 and 7, and are modified from the traditional format in that they include data from all the wells in a given direction (e.g., east-to-west), rather than along a given plane (i.e., lateral distances between wells were not considered). Plan-view maps showing total VOC, CCl₄, and Freon 113 concentrations with depth at the locations sampled were also prepared. Cross sections prepared for Events 2 and 3 show total VOC concentrations in the north-central portion of the site (where they are the highest), and near the southeastern and eastern edges of the site. For Events 4 and 5, during which a limited number of wells were sampled, only maps showing total VOC and CCl₄ concentrations with depth at the locations sampled were prepared. Similar maps were prepared for Events 6 and 7 (showing total VOCs only) and are included with the envelope maps, the schematic cross-sectional diagrams, and the traditional cross sections depicting total VOC, CCl₄,

and Freon 113 concentrations across the north-central part of the site. The rationale for using this approach as opposed to presenting soil-vapor concentration contour maps or three-dimensional (3-D) representations is explained below.

First, development and verification of a comprehensive "vapor plume" using concentration contour maps or 3-D representation was not feasible because different sets of wells were sampled during various events (see the above table). As the table shows, the purpose of Events 6 and 7 was to study a specific zone of elevated VOC concentrations within the area identified previously in Events 2 and 3. Therefore, the sets of soil-vapor wells sampled during Events 6 and 7 encompassed an area smaller than that of the wells sampled in Events 2 and 3. Furthermore, as specified in Addendum No. 2 to the FSAP (FWENC, 1998b), several wells, which were sampled in Event 6, were not sampled in Event 7. Consequently, if concentration contour maps were prepared for Events 2 and 3, they would be insufficient based on the more recent data collected in Events 6 and 7. In addition, concentration contour maps for Events 6 and 7 would only include a portion of the area identified in Events 2 and 3. Finally, the data from Events 2 and 3 could not be used in combination with the data from Events 6 and 7 to define a comprehensive "vapor plume," as the events were separated temporally by more than 3 years and the data were not collected at the same sampling points. To account for this, the envelope maps constructed for Events 6 and 7 also contain the envelopes developed for Events 2 and 3 to convey the most recent data and to provide the most complete representation of the lateral extent of VOC vapors in the subsurface.

Secondly, the data is such that detects are somewhat sporadic and variable depending on the compound and the depth from which the samples were collected. Presentation of the data using concentration contour maps or 3-D plume maps would, therefore, show specific pockets of VOC vapors, the boundaries of which could not be verified. Therefore, presentation of this data using concentration contour maps or 3-D plume maps could imply a level of detail that may be misleading. This is compounded by spatial variability with regard to soils, topographic relief, and distribution of VOC vapors within the soils, as well as the inherent mobility of soil vapor. The figures presented in this section provide an appropriate level of detail to adequately characterize the lateral and vertical extents of VOC vapors in the soils at JPL as established in Section 1.0.

During the course of the OU-2 RI, four VOCs were more frequently detected in soil-vapor samples at elevated concentrations relative to other VOCs. These four VOCs are carbon tetrachloride (CCl_4), trichloroethene (TCE), 1,1-dichloroethene (1,1-DCE), and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113). The discussions of VOCs detected in soil-vapor samples in the following four subsections include all compounds, but individual discussions on the four primary compounds identified are presented in detail. Furthermore, CCl_4 was detected in most soil-vapor samples where VOCs were present and often was the only VOC detected. In addition, CCl_4 was most frequently detected at higher concentrations than other VOCs.

An envelope map for Events 2 and 3 depicts the four most prevalent VOCs as well as total VOCs. Based on the results from Events 2 and 3, CCl₄ concentrations at soil-vapor well No. 16 were elevated compared to all other VOCs, and, therefore, the maps for Events 4 and 5 depict the total VOCs and CCl₄ in the vapor wells adjacent to well No. 16 (i.e., Nos. 25 through 28). Individual envelope maps and modified schematic cross sections were prepared for CCl₄, TCE, 1,1-DCE, and Freon 113 for Events 6 and 7. The maps for Events 6 and 7 also include envelopes from Events 2 and 3, as both depict the lateral (areal) extent of VOC vapors based on the soil-vapor wells sampled. Finally, additional maps prepared for Events 6 and 7 show the locations of VOC detections, and the total VOC concentrations with depth.

Where groundwater elevations are shown on any of the modified schematic cross sections or on the traditional horizontally scaled cross sections, those elevations have either been estimated from groundwater contour maps and other information developed during the OU-1/OU-3 RI studies or based on actual depth-to-groundwater measurements taken in nearby groundwater monitoring wells during the soil vapor sampling event. All estimated groundwater elevations are considered to be approximate; however, these elevations are believed to be representative of the groundwater levels that existed during the time of soil-vapor sampling. Elevations shown for perched groundwater are based on the actual depth that perched groundwater was encountered during drilling.

4.2.1 Sampling Event 1: Soil-Vapor Probes

Results of the initial soil-vapor probe screening (Event 1) are presented in Table 4-5. VOCs were detected in 19 of the 57 samples. Carbon tetrachloride, TCE, and small concentrations of chloroform were frequently detected. Several other compounds were sporadically detected at low concentrations as indicated in Table 4-5. The locations of soil-vapor probes where VOCs were detected are shown in Figure 4-5, and as indicated, most of the detections were located in the northeastern portion of the site with the exception of SV-4, which is located in the north-central portion of the site. Based on the analytical data for Event 1, areal envelopes were assessed for total VOCs, CCl₄, TCE, and chloroform, and are shown in Figure 4-6. The highest concentrations of CCl₄ were found in probes SV-31, SV-32, and SV-33 (51.6 to 89.1 µg/L-vapor) in the northeast portion of the site. These probes are associated, respectively, with seepage pit or dry well Nos. 31, 36, and 37 (see Figure 4-1).

The highest concentration of TCE (53.3 µg/L-vapor) was found in SV-17, south-southwest of the area with high CCl₄ levels, and is associated with seepage pit No. 29 (Figure 4-1). Also, as shown in Figure 4-5, no VOCs were detected in the soil-vapor probes associated with the three potential waste disposal areas (WP-1, WP-2 and WP-3) identified prior to Event 1. See Appendix B for analytical (laboratory) reports for Event 1.

4.2.2 Sampling Events 2 and 3: Soil Vapor Well Nos. 1 through 24

Analytical results from Events 2 and 3 are presented in Table 4-6. Frequently detected compounds in Events 2 and 3 included CCl₄, TCE, and Freon 113. Similar to Event 1, other

chlorinated VOCs [including chloroform, tetrachloroethene (PCE), and various dichlorinated aliphatic hydrocarbons] were sporadically detected. Additionally, detections of benzene, ethylbenzene, toluene, and xylenes (BTEX compounds) from the deepest sampling tip in soil vapor well No. 17 (associated with seepage pit No. 34), indicate that potential contamination may be present at the east end of the solid propellant preparation area (Buildings 86, 87, 89, and 98) where a pit was reportedly used for the disposal of solvents and other chemicals after the sewer system was installed.

Using data from Events 2 and 3, areal envelopes were assessed for total VOCs, CCl_4 , TCE, 1,1-DCE, and Freon 113 and are shown in Figure 4-7. For both events, the minimum known areal distribution for each of these constituents was assessed using concentrations greater than the detection limit ($1.0 \mu\text{g/L}$) at any depth. The horizontal extent of chlorinated VOCs in JPL soils was confirmed in the northeastern part of the site; however, the southern and western boundary of the envelope was extended based on the detections CCl_4 , TCE, and Freon 113 in well Nos. 8, 18, and 19A. Areas with the highest total concentrations (greater than $100 \mu\text{g/L}$ -vapor) were identified in the vicinity of well No. 16 (CCl_4 and other chlorinated VOCs) and No. 17 (chlorinated VOCs and BTEX compounds). Concentrations at depth (where detected) for total VOCs and the most significant compounds, CCl_4 and Freon 113, are shown in Figures 4-8, 4-9, and 4-10, respectively.

To illustrate the vertical extent of VOC vapors, a schematic cross-section showing elevations of sampling tips in soil vapor well Nos. 1 through 24, along with VOC vapor concentrations measured at each soil vapor sampling tip, is presented in Figure 4-11. For locations where these VOCs were detected in only one event, the concentration from that event was used. Also, for a given location, the higher concentration from the two events was used. It is indicated in these figures that VOC vapors occur at depth beneath the site. The highest total concentration measured during Events 2 and 3 was in well No. 16 (including $240 \mu\text{g/L}$ -vapor of CCl_4) at a depth of approximately 100 feet. The cross sections prepared for Events 2 and 3 show total VOC concentrations where they are the highest across the north-central portion of the site (Figure 4-12), concentrations in the southeastern part of the site (Figure 4-13), and along the eastern edge of the site (Figure 4-14).

VOCs were also detected at their highest concentrations at the bottom of other soil-vapor wells, as exemplified by CCl_4 in well No. 16, indicating that the vertical extent of VOC vapors needed further characterization. This further characterization is described in Section 4.2.3. See Appendices C1 and C2 for laboratory reports for Events 2 and 3, respectively.

4.2.3 Sampling Events 4 and 5: Soil Vapor Well Nos. 25 through 31

The vertical and lateral extents of high VOC concentrations in the vicinity of well No. 16 were further investigated by installing soil vapor well Nos. 25 through 28 to groundwater at the locations shown in Figure 4-15. These four wells were constructed with soil vapor sampling tips ranging in depths from 20 feet to 195 feet. Three additional soil-vapor wells (Nos. 29, 30, and 31) were installed along the eastern edge of the site. Of these, No. 30 and No. 31 were

installed within suspected waste pits or trenches (WP-4 and WP-5) identified in old aerial photographs (see Figure 4-1 for locations of WP-4 and WP-5). Well No. 29 was installed near a suspected discharge point (DP-2) identified in a City of Pasadena inspection report. Vapor samples from soil vapor well Nos. 25 through 31 were collected and analyzed in Events 4 and 5.

Results from Events 4 and 5 are presented in Table 4-7 where it can be seen that CCl_4 , TCE, 1,1-DCE, and Freon 113 were the most frequently detected analytes. Laboratory reports for Events 4 and 5 are presented in Appendices C3 and C4, respectively. Several other chlorofluorocarbons and chlorinated aliphatic compounds were also detected; however, detections of these compounds were sporadic and concentrations were only slightly in excess of the analytical detection limit of 1.0 $\mu\text{g/L}$ -vapor.

The concentrations of total VOCs and CCl_4 detected in soil-vapor wells sampled during Events 4 and 5 are tabulated on Figures 4-15 and 4-16, respectively. High VOC and CCl_4 concentrations were measured in all four wells installed in the suspected high VOC concentration area around soil vapor well No. 16. Analytical results from three of these wells (Nos. 25, 26, and 28) showed an initial concentration increase with depth from about 60 feet to 140 feet and then was followed by a subsequent decrease with further depth. Conversely, in soil vapor well No. 27, concentrations continued to increase with depth with the highest concentrations occurring in the deepest probe at a depth of 205 feet. No VOCs were detected in soil vapor well Nos. 29, 30, and 31 along the eastern edge of the site.

4.2.4 Sampling Event 6: Soil Vapor Well Nos. 25 through 28 and Nos. 32 through 39

Four deep soil-vapor wells (Nos. 32 through 35) were installed to further assess the high VOC concentrations around well Nos. 25 through 28 and in the vicinity of groundwater monitoring well MW-7. Four additional deep wells (Nos. 36 through 39) were installed to assess the possibility of VOC vapors from another plume, or plumes, that may be contributing to the VOC concentrations measured in groundwater samples collected from groundwater monitoring wells MW-13 and MW-16. Locations of these eight new deep soil-vapor wells are shown in Figure 4-17. These eight new wells, along with well Nos. 25 through 28, were sampled during Event 6.

All of these deep soil-vapor wells were drilled to groundwater and the bottom sampling ports were installed several feet above the groundwater table at the time of installation. Because of the extraordinary wet winter and spring of 1998, the water table raised higher and more quickly than usual. Hence, the lowermost sampling ports in all of the deep soil-vapor wells except Nos. 34, 35, and 36 were inundated by groundwater. It was possible to blow into the ports with the sampling syringe during Event 6 (also during Event 7), but the ports could not be purged.

Results from Event 6 are compiled in Table 4-8. Similar to previous sampling events, CCl_4 , TCE, 1,1-DCE, and Freon 113 were frequently detected, and several other chlorofluorocarbons and chlorinated aliphatic compounds were sporadically detected at concentrations exceeding the

analytical detection limit of 1.0 µg/L-vapor. The locations of VOC detections, and the total VOC concentrations with depth are shown in Figure 4-17.

Based on results from analyses conducted during Event 6, separate figures illustrating the lateral and vertical extents of CCl₄, Freon 113, TCE, and 1,1-DCE vapors, are depicted in Figures 4-18 through 4-25, respectively. Graphs for volatile organic compounds of potential concern detected at depth during Event 6 are presented in Appendix E1. Analytical (laboratory) data for Event 6 are presented in Appendix C5.

Because the purpose of Event 6 was to further characterize the area of highest VOC concentration, wells in which organic vapors were detected during Events 2 and 3 were not sampled in Event 6. Therefore, the envelope for a particular compound identified in Events 2 and 3 is included on the Event 6 compound-specific maps to comprehensively illustrate the estimated lateral distribution of VOC vapors.

Carbon Tetrachloride

The minimum known areal distribution of CCl₄ vapors, based on data from the soil-vapor wells sampled during Event 6 and the CCl₄ envelope that is based on data from Events 2 and 3, are depicted in Figure 4-18. As shown in Figure 4-18, the lateral extent of CCl₄ vapors near soil vapor well No. 16 is more extensive than was depicted by Events 4 and 5 (Figures 4-15 and 4-16). In addition, the detects in soil vapor well Nos. 36, 37, 38, and 39 confirm the extent of CCl₄ vapors toward the western portion of the envelope previously identified in Events 2 and 3.

The vertical distribution of CCl₄ vapors is illustrated in Figure 4-19. As shown in Figure 4-19, there was an initial increase in concentrations with depth followed by a subsequent decrease with further depth. The highest concentrations typically occurred between depths of 100 and 180 feet bgs (concentrations of CCl₄ in Nos. 25, 26, 27, 28, 33, 34, and 35 ranged from non-detect to 404 µg/L-vapor [No. 28]). The presence of VOCs in the deeper probes indicates that VOC vapors are present through much of the vertical extent of the sample zones (deeper than 20 feet bgs). All probes with elevations below approximately 1020 feet above mean sea level were water plugged, indicating that the groundwater table was probably present at about that depth during the time of sampling.

Freon 113

The minimum known areal distribution of Freon 113 vapors based on data from the soil-vapor wells sampled during Event 6, is depicted in Figure 4-20. Similar to CCl₄, the Freon 113 envelope based on data from Events 2 and 3 is also shown. Freon 113 is present in the central portion of the site, and the highest concentrations (greater than 100 µg/L-vapor) occur in the vicinity of soil vapor well No. 32. The shape of the envelope is similar to the CCl₄ envelope shown in Figure 4-18.

Based on the Event 6 data, the vertical distribution with depth of Freon 113 vapors is illustrated in Figure 4-21. This figure shows that Freon 113 is generally present at depths ranging from 20 feet to 180 feet. As was observed with CCl_4 , Freon 113 concentrations increased initially with depth in a number of wells, and then was followed by a subsequent decrease with further depth.

Trichloroethene

The minimum known areal distribution of TCE vapors, based on results from the soil-vapor wells sampled during Event 6, is depicted in Figure 4-22. The TCE envelope that is based on data from Events 2 and 3 is also shown. Results from Event 6 showed that TCE vapors are present in the central portion of the site, and results from earlier events indicate that it is present in the northeastern portion as well. TCE was not detected at concentrations exceeding 100 $\mu\text{g/L}$ -vapor anywhere on site during Event 6; however, the highest concentrations (approximately 50 $\mu\text{g/L}$ -vapor) were measured in the northeast portion of the site during Events 2 and 3 in soil vapor well No. 4. None of the TCE concentrations measured in the central portion of the site during Event 6 exceeded 10 $\mu\text{g/L}$ -vapor with the exception of soil vapor well No. 39, in which TCE was measured at 19 $\mu\text{g/L}$ -vapor at a depth of 120 feet.

Based on Event 6 data, the vertical extent of TCE is illustrated in Figure 4-23. It is shown in this figure that TCE is generally present at depths ranging from 20 to 180 feet.

1,1-Dichloroethene

The minimum known areal distribution of 1,1-DCE vapors, based on data from the soil-vapor wells sampled during Event 6, is depicted in Figure 4-24. The 1,1-DCE envelope based on data from Events 2 and 3 is also shown. During Event 6, 1,1-DCE was detected in only three wells located in the central portion of the site. Concentrations in these three wells did not exceed 10 $\mu\text{g/L}$ -vapor, and the highest concentrations of 1,1-DCE (approximately 10 $\mu\text{g/L}$ -vapor) occur in soil vapor well No. 33. Results from Events 2 and 3, as well as Events 4 and 5, suggest that the 1,1-DCE envelope radiates outward from the wells sampled during Event 6 at lower concentrations.

The vertical range of 1,1-DCE vapors is illustrated in Figure 4-25 and is based on data from Event 6. It is shown in this figure that 1,1-DCE is generally present throughout most of the depths sampled in well Nos. 26 and 33.

4.2.5 Sampling Event 7: Soil Vapor Well Nos. 32 through 39

Results from Event 7 are presented in Table 4-9. The locations and total VOC concentrations are shown in Figure 4-26. Graphs for volatile organic compounds of potential concern detected at depth during Event 7 are presented in Appendix E2. Similar to Event 6, CCl_4 , TCE, 1,1-DCE, and Freon 113 were the most frequently detected analytes in the soil vapor. While several other chlorofluorocarbons and chlorinated aliphatic compounds were sporadically detected, they were generally at lower concentrations. The locations and concentrations of analytes detected in soil vapor during Event 7 were similar to those for Event 6. Also, the same sampling ports that were

water plugged during Event 6 remained inundated by groundwater during Event 7. Analytical (laboratory) data for Event 7 are presented in Appendix C6.

Based on results from analyses conducted during Event 7, figures illustrating the minimum known areal distribution and vertical extent of soil vapors for CCl_4 , Freon 113, TCE, and 1,1-DCE are presented in Figures 4-27 through 4-34. Because the purpose of Event 7 was to confirm the minimum known areal distribution of VOC vapors in the area of highest concentrations previously identified, some of the soil-vapor wells where organic vapors were detected during Events 2, 3, and 6 were subsequently not sampled in Event 7. Therefore, compound-specific envelopes identified in Events 2 and 3 are included on the Event 7 envelope maps to comprehensively present the estimated distribution of VOC vapors in the soil. The area encompassing the soil-vapor wells sampled in Event 6 (Nos. 25 through 29), but not during Event 7, is included in the area encompassed by the compound-specific envelopes for Events 2 and 3. Therefore, envelopes based on Event 6 data were not included in Figures 4-27 through 4-34, and the overall delineation of VOC vapor distribution was not affected.

Carbon Tetrachloride

The minimum known areal distribution of CCl_4 vapors, based on the sampling results from Event 7, is shown in Figure 4-27. The CCl_4 envelopes for Events 2 and 3 are also shown. Figure 4-27 shows that the CCl_4 vapor distribution delineated in Event 6 is confirmed in the central portion of the site during Event 7, and the area with the highest concentrations (greater than 100 $\mu\text{g/L}$ -vapor) is located in the north-central portion of the site.

The vertical distribution with depth of CCl_4 vapors detected in Event 7 is illustrated in Figure 4-28, and it can be seen that the CCl_4 distribution delineated for Event 6 (see Figure 4-18) was confirmed, although concentrations in soil vapor well No. 32 did exceed 100 $\mu\text{g/L}$ -vapor in Event 7 but did not exceed 100 $\mu\text{g/L}$ -vapor in Event 6.

Freon 113

Based on data from the soil-vapor wells sampled during Event 7, the minimum known areal distribution of Freon 113 vapors is shown in Figure 4-29. The Freon 113 envelope that is based on data from Events 2 and 3 is also shown. Sampling results from Event 7 confirmed the presence of Freon 113 beneath the central portion of the site where the highest concentrations (greater than 100 $\mu\text{g/L}$ -vapor) occur in the vicinity of soil vapor well No. 32. Freon 113 was also detected in this area during Event 6, and the shape of the envelope for Event 7 is similar to that shown for Event 6 (see Figure 4-20).

As illustrated in Figure 4-30, the vertical distribution with depth of Freon 113 vapors for Event 7 is similar to that shown in Figure 4-21 for Event 6.

Trichloroethene

The minimum known areal distribution of TCE vapors is based on results from the soil-vapor wells sampled during Event 7 and is illustrated in Figure 4-31. The TCE envelope from Events 2

and 3 is also shown. Results from Event 7 show that TCE vapors are present in the central portion of the site, and earlier results indicated that it was also present in the northeastern portion of the site. TCE was not detected at concentrations exceeding 100 µg/L-vapor anywhere on the site during Event 7. TCE was not detected in soil vapor well No. 32 during Event 6, but was detected at depths of 155 and 180 feet at concentrations slightly above the analytical detection limit of 1.0 µg/L-vapor during Event 7.

Based on sampling results, the vertical extent and distribution with depth of TCE for Event 7 is illustrated in Figure 4-32, and it is evident that these distributions are very similar to those determined in Event 6 (see Figure 4-23) with the exception of soil vapor well No. 32 to the northeast.

1,1-Dichloroethene

The minimum known areal distribution of 1,1-DCE vapors, based on data from Event 7, is presented in Figure 4-33. Also shown is the 1,1-DCE envelope as based on data from Events 2 and 3. During Event 7, 1,1-DCE was detected only in soil vapor well No. 33 located in the north-central portion of the site (well Nos. 25 and 26, which contained 1,1-DCE during Event 6 were not sampled in Event 7). Concentrations up to 20 µg/L-vapor were measured in vapor sampled from soil vapor well No. 33 during Event 7.

The vertical extent and distribution with depth of 1,1-DCE for Event 7 is illustrated in Figure 4-34, and, as shown, the distribution of 1,1-DCE with depth is generally similar to that from Event 6 (see Figure 4-25).

4.2.6 Summary of Results from Events 6 and 7

Results from Events 6 and 7 provided further indication of a VOC plume located primarily beneath the central and eastern portion of the site extending to the groundwater table and consisting largely of CCl₄, Freon 113, TCE, and 1,1-DCE. To better depict the vertical extent of VOCs with respect to the water table, cross sections summarizing results of Events 6 and 7 were prepared for total VOCs, CCl₄, and Freon 113, and are presented as Figures 4-35, 4-36, and 4-37. For each given sampling port, the higher concentration from the two events was used. Data presented in these figures suggest that VOCs extend to the groundwater table over much of the area in the central and eastern portions of the site.

4.3 SOIL SAMPLE RESULTS

Included in this section is a summary and evaluation of the chemical data pertaining to the nature and extent of metals and organic compounds detected in soil samples collected at JPL. Soil samples were collected during two drilling rounds (see table in Section 4.1.2). However, for the reasons discussed in Section 4.2, the results from laboratory analyses from both soil sampling rounds are considered together in the following discussions. The analytical data from these RI sampling rounds are included in Appendices D1 and D2. Finally, as described in Sections 3.1 and 3.3.2.2, test pit Nos. 1, 2 and 3, which were originally excavated and sampled on April 14,

1997, were reexcavated and resampled on June 10, 1999. In the following discussions regarding test pit Nos. 1, 2, and 3, the sampling locations designated as TP-1, TP-2, and TP-3, respectively, refer to the original excavation and sampling locations. Locations designated as TP-1A, TP-2A, and TP-3A refer to the reexcavation and resampling of test pits Nos. 1, 2, and 3 (see Figure 4-3 for locations of test pits). The analytical data from the reexcavation and resampling of test pits Nos. 1, 2, and 3 (i.e., TP-1A, TP-2A, and TP-3A) are included in Appendix D3.

4.3.1 Background Geochemistry for Soil

Described in this section is the evaluation of background soil geochemistry used to assess the nature and extent of potential contamination resulting from activities at JPL. The evaluation included the development of background values for soil samples collected during the field sampling program. These background values were based on the analytical method reporting limit or the maximum concentration reported for each inorganic constituent in the background data set.

The determination of background geochemistry is important because even natural levels of some metals in soil at JPL could result in human health risk calculations that exceed regulatory guidelines. Objective methods are therefore necessary for evaluating background concentrations of metals. Metals concentrations in soil samples from potential source areas investigated can then be compared to the background values (or other guidance) to identify contaminant releases that may have occurred.

4.3.1.1 Background Soil Data Set

Soil samples collected at two background locations were similar in grain size and chemical composition to those soil samples collected at the investigated potential source locations. The background locations were in areas unaffected by activities at JPL. The background soil data set is composed of analytical results for samples collected beneath the western parking lots at JPL at the locations shown in Figure 4-3. Five soil samples were collected at locations BG-1, BG-1A, BG-2, and BG-2A. Samples from soil borings BG-1 and BG-2 were analyzed for Title 26 Metals plus strontium, VOCs and SVOCs. Samples from BG-1A and BG-2A were analyzed for Title 26 Metals plus strontium and hexavalent chromium (see Section 2.3.3.1) and total solids to determine percent moisture. Analytical results for Title 26 Metals plus strontium and hexavalent chromium for the background samples are presented in Table 4-10.

4.3.1.2 Background Soil Geochemistry Results

A total of nineteen metals were included in the analyses for the five background soil samples collected. Since only five samples were collected, the maximum detected concentration of each metal was used as a background value. If a metal was not detected in any of the background samples, the method detection limit was used as a background value. Thus, any metals detected in a soil sample that were not detected in a background sample are considered greater than background in the area. Presented in Table 4-11 are the range of metal detections in the background soil samples compared to ranges of concentrations reported for typical California

soils (Bradford and others, 1996) and those reported for typical soils in the western conterminous United States (Shacklette and Boerngen, 1984). The concentrations of metals in background soil samples fall within the range of values reported.

4.3.2 Title 26 Metals

Results from the analysis of Title 26 Metals are presented in Table 4-10. All metals included in the suite of analyses for Title 26 Metals, plus strontium and hexavalent chromium, were detected in JPL soils with the exception of selenium. Where detected, metal concentrations were reasonably well correlated within the range of typical soil background levels. Arsenic (As) was detected at levels slightly elevated over the measured background values but well within the range measured for other California soils, and hexavalent chromium [Cr(VI)], which is generally not considered to occur naturally, was detected at four locations.

Arsenic was detected in 120 out of a total of 122 soil samples collected. The average As concentration for these 120 samples was 3.8 milligrams per kilogram (mg/kg). Arsenic was detected in three of five background soil samples at concentrations ranging from 2.0 mg/kg to 2.2 mg/kg. Since the method detection limit was 10 mg/kg for the two background samples in which As was not detected, it is likely that these two samples also contained As. Concentrations of As in soil ranged from a minimum of 1.1 mg/kg in soil boring No. 31 at a depth of 10 feet to a maximum of 20.0 mg/kg in soil boring No. 13 at a depth of 30.5 feet. Seventy-two percent of the samples collected had concentrations less than the arithmetic mean of 3.8 mg/kg. The widespread distribution of As in soil, both laterally and vertically, does not show any trends that indicate one or more potential contaminant source areas as a contributor of As to the site. The consistent occurrence of this metal throughout all soil at JPL, including background, indicates that As is most likely a naturally occurring soil constituent attributable to the igneous source rock of the nearby mountains.

Hexavalent chromium [Cr(VI)] was detected in soil boring No. 29 at depths of 4, 10, and 15 feet at concentrations of 0.28, 0.01, and 0.03 mg/kg, respectively, and in test pit Nos. 1A, 2A, and 3A at concentrations ranging from 0.08 mg/kg to 0.84 mg/kg (see Table 4-10 and Figure 4-3). No historic information on JPL operations was found to support the presence of Cr(VI) at these locations. Hexavalent chromium is one of the two common oxidation states of chromium. Chromium is a naturally occurring transition metal that is present over a wide concentration range in soils throughout the world. The two oxidation states of chromium in environmental systems are: (1) the trivalent state, Cr(III), which exhibits relatively low toxicity and low mobility; and (2) the hexavalent state, Cr(VI), which is considered to be more toxic and more mobile. In most soil-water systems, Cr(VI) is present as the highly soluble chromate ion (CrO_4^{2-}) and is significantly less stable [subject to rapid biotic and abiotic reduction to Cr(III)] than Cr(III), which tends to form insoluble precipitates at pH levels above 5.5 (Losi and others, 1994). Naturally occurring chromium is overwhelmingly observed as Cr(III).

of two SW-846 methods: EPA Method 8270 for SVOCs and EPA Method 8310 for PAHs. The PAHs detected in soil samples are as follows:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Chrysene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene

Fluoranthene and pyrene were detected in soil boring No. 12 at a depth of 10 feet with concentrations of 110 and 100 $\mu\text{g/kg}$, respectively. Benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, and benzo(g,h,i)perylene were detected at a depth of 10 feet in soil boring No. 30, located at WP-4, at concentrations ranging from 3.6 $\mu\text{g/kg}$ to 11 $\mu\text{g/kg}$.

Samples from TP-2, excavated at discharge point No. 1 (DP-1), contained benzo(b) fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene at concentrations of 6.4 $\mu\text{g/kg}$, 48 $\mu\text{g/kg}$, and 67 $\mu\text{g/kg}$, respectively, using EPA Method 8310. PAHs detected in samples from TP-2 by using EPA Method 8270 included phenanthrene, fluoranthene, and pyrene that were detected at concentrations of 22 $\mu\text{g/kg}$, 46 $\mu\text{g/kg}$, 55 $\mu\text{g/kg}$, respectively. Benzo(a)anthracene, benzo(b)fluoranthene, chrysene, fluoranthene, and phenanthrene were detected (EPA Method 8310) at concentrations of 7.7 $\mu\text{g/kg}$, 8.8 $\mu\text{g/kg}$, 18 $\mu\text{g/kg}$, 24 $\mu\text{g/kg}$, and 12 $\mu\text{g/kg}$, respectively, in the sample collected from a depth of 1 foot in TP-2A.

Benzo(a)pyrene, and benzo(g,h,i)perylene were detected in samples collected from TP-3 located near DP-4 at concentrations of 4.2 $\mu\text{g/kg}$ and 11 $\mu\text{g/kg}$, respectively.

PAHs detected in soil samples collected at or near DP-1, DP-4, and WP-4 can be attributed to waste disposal activities in these areas. In test pit samples, PAHs were detected at higher concentrations in the near-surface samples and the concentrations decreased with depth. In all cases where PAHs were detected, in either soil borings or test pits, PAHs were not detected in the next deeper sample analyzed.

4.3.5 Polychlorinated Biphenyls

Results from the analysis of polychlorinated biphenyls (PCBs) in samples from soil boring Nos. 29, 30, and 31 and TP-1, TP-2, TP-3, TP-1A, TP-2A, and TP-3A, which are located in suspected waste disposal areas, are presented in Table 4-14 and Figure 4-38. As shown, PCBs were detected in only 3 of the 42 samples. Two congeners, Arochlor-1254 and Arochlor-1260, were detected at depths of 1 and 5 feet in TP-2 that was excavated near DP-1. An additional congener, Arochlor-1232 was detected at a depth of 5 feet in TP-2A.

4.3.6 Dioxins and Furans

Dioxin and furan results from the analysis of samples from soil borings Nos. 29, 30, and 31 and TP-1, TP-2, TP-3, TP-1A, TP-2A, and TP-3A are presented in Table 4-15 and Figure 4-38. Results show that the dioxin congener 1,2,3,4,6,7,8,9-OCDD was detected only in TP-2 and TP-2A, located near DP-1, at a depth of 1 foot (Figure 4-38). Dioxins and furans were not detected in any other soil samples collected at JPL during the OU-2 RI field program.

4.3.7 Volatile Organic Compounds

The only soil samples analyzed for VOCs during the OU-2 RI were those collected from the test pits. Sampling of the test pits occurred during the second drilling event and during the subsequent reexcavation of the pits (refer to Sections 4.1.2 and 4.1.3.2). Results of these analyses are summarized in Table 4-16, and a complete set of results for VOCs is presented in Appendix F3. VOCs were not detected in samples collected during the second drilling event with the exception of dichloromethane (methylene chloride) at concentrations equal to or below the reporting limit. Dichloromethane (methylene chloride) was also detected in one associated method blank and the detections are attributable to laboratory contamination.

Acetone, bromodichloromethane, and chloroform were detected in soil samples collected during the reexcavation of the pits. All detections of these compounds were below the reporting limits. Because acetone is a common laboratory contaminant, and was detected in one of the associated method blanks, its presence in the soil samples is most likely due to laboratory contamination. Chloroform and bromodichloromethane are common constituents of chlorinated public water supplies. These compounds were detected in test pit Nos. 1A and 2A, which currently receive outflow from the JPL facility, including irrigation water and storm run-off, and this likely explains their presence in the soil samples.

4.3.8 Total Petroleum Hydrocarbons

Total petroleum hydrocarbons (TPH) results from EPA Method 418.1 analyses of soil samples are included in Table 4-17 and Figure 4-38. TPH were detected in 14 soil borings at the locations and concentrations shown on Figure 4-38. This method is specific for the hydrocarbons greater than C10, thus VOCs such as BTEX compounds, will not be detected. Consequently, these results do not correlate with the VOC sampling and analysis of soil vapor following conversion of these boreholes to soil-vapor wells (soil vapor sampling Events 2 and 3). In addition, SVOCs were not detected in any of the soil borings where TPH were found even though some of the heavier SVOCs (including PAHs) contain more than 10 carbon atoms. This suggests that the TPH detected in samples, other than the one from a depth of 20 feet in soil boring No. 1, may be indicative of the presence of a heavy oil such as lubricating or mineral oil (C18 through C20). The high concentration (6,500 µg/kg) of TPH in the sample from soil boring No. 1 is due to the presence of sand-sized asphalt particles contained in the materials used to backfill seepage pit No. 2 from 17 to 21 feet below ground surface.

4.3.9 Cyanide and Nitrate

Results of cyanide (CN^-) and nitrate (NO_3^-) analyses are also presented in Table 4-17. Cyanide was detected in three samples from soil boring No. 30 at concentrations ranging from 74 $\mu\text{g/kg}$ to 85 $\mu\text{g/kg}$ (see Figure 4-38). As shown in Table 4-16, NO_3^- was detected in virtually all soil borings. The widespread occurrence of NO_3^- in JPL soils can be attributed to the use of agricultural fertilizers in cropland plus equestrian activities prior to the establishment of JPL, fertilizer usage by JPL in landscaped areas, irrigation waters, as well as the historic use of cesspools on the site.

4.3.10 Tributyltin

Tributyltin was detected at the reporting limit of 1 $\mu\text{g/kg}$ in both soil samples collected from test pit No. 2A at depths of 1 foot and 5 feet. These results are included in Table 4-17.

4.3.11 Gross Alpha and Gross Beta

Results from gross alpha and gross beta analyses of soil samples are presented in Table 4-17. Levels ranged from 1.7 to 6.3 picocuries/gram of soil (pCi/g) and the highest level was measured at 70.5 feet in soil boring No. 19A. Gross alpha and beta results are a measure of non-penetrating alpha and beta particles emitted as a result of the decay of radioactive isotopes contained in soil materials derived from granitic rocks.

4.4 DATA QUALITY ASSURANCE AND QUALITY CONTROL

The QA/QC specifications described in the QAPP (Ebasco, 1993e) and Addendum to the QAPP (FWENC, 1996e) were applied and implemented during scientific work associated with this investigation. These specifications were developed from the requirements set forth in EPA's *Data Quality Objectives for Remedial Response Activities* (EPA, 1988), and the State of California's quality assurance/quality control guidance document for well investigation programs (RWQCB, 1992). Project-specific Data Quality Objectives (DQOs) provide the context for understanding the purpose of the data collection effort and establish qualitative and quantitative criteria for assessing the quality of the data set in terms applicable to the intended use. In this way, DQOs become the relevant yardstick for judging whether or not the data set is adequate. A programmatic quality assessment can also be made based on the degree to which various subtasks (e.g., field collection of soil and vapor samples, laboratory analysis, and data reporting) were performed under controlled conditions as prescribed in the work plans.

The ultimate goal of the data quality assessment process is to address the data user's decision-making requirements. Therefore, the overall objective was to generate sufficient control data to allow quantitative evaluation/assessment of the "reasonableness" of the environmental database in terms of type, quality, and quantity necessary to support its intended use.

Foster Wheeler Environmental Corporation has structured its program organization to maintain control and assure the quality of its performance and that of its subcontractors during the remedial investigation. As a totally independent body, the purpose of Foster Wheeler Environmental's Quality Control Organization is to ensure compliance with all programmatic (QA/QC) requirements. Described in this section are the specific QA/QC checks that were implemented during the RI for OU-2 in order to comply with project requirements and assure that project DQOs were achieved. The QA/QC checks included field and laboratory-generated control samples and data validation.

4.4.1 Data Quality Objectives

The DQO development process is described in the project QAPP (Ebasco, 1993e). Investigative activities, sampling locations, and general field conditions during OU-2 are similar to those that occurred during OU-1 and OU-3. The only significant variable is the type of data. Each distinct sample matrix (e.g., groundwater, soil, soil vapor) generates a different data type, and these vary among operational units because of the focus of the investigation. Most importantly, the intended uses of the data are essentially the same among all three units. Therefore, DQOs established for those operational units were applied universally to the project and, specifically, to the OU-2 remedial investigation.

The fundamental goals of the project DQOs were to acquire data of sufficient quality and quantity to accomplish the following OU-2 objectives:

- Characterize the types of contaminants and their lateral and vertical extents in the soil at JPL.
- Provide determinations whether or not identified potential source areas could impact on-site groundwater beneath JPL.
- Provide sufficient information for the OU-2 FS to identify feasible technologies for potential remediation of the vadose zone at JPL.
- Provide sufficient information on surface soil to a depth of 2 feet to facilitate preparation of human health and ecological risk assessment.
- Provide sufficient information to facilitate preparation of an assessment on the present and future risks to public health and the environment associated with exposure to on-site soil and soil vapor.

4.4.2 Field Quality Assurance/Quality Control

Control samples of various types were collected during each sampling event or round. Field-generated QC samples included field blanks, equipment rinseate blanks and duplicates on soil and soil-vapor samples.

In order to assess the probability and magnitude of the potential for background contamination of soil-vapor samples, one ambient air sample was collected and analyzed at the beginning of each day of soil-vapor sampling. None of the target VOC contaminants were detected in any of these

laboratory blanks. The data from the field blanks indicate that no detectable impact to the concentrations of target VOCs in soil-vapor samples occurred as the result of environmental conditions present during laboratory analysis performed on the site.

In the case of soils, five background samples (SS-1 through SS-5) were collected and analyzed for target metals in order to estimate baseline levels of metals in a representative but presumably uncontaminated soil matrix. In addition, one sampling equipment rinse blank was prepared each sampling day. Data from equipment rinse blanks were used to assess potential cross contamination between discreet boring samples because of improper decontamination of field sampling equipment, container contamination, contamination introduced during shipment or handling of the samples, or during preparation of samples for analysis. A total of seven aqueous rinse blanks were generated for this purpose. Trace concentrations of several metals (Ba, Be, Cr, Ni, Sr and Pb) were detected below the laboratory reporting limit, but quantities were insignificant. Zinc was the only element consistently found above the reporting limit, and then only at very low levels (approximately 30 µg/L). All blank concentrations were below MCLs and therefore not significant. No data were qualified due to contamination of equipment blanks. Overall, the equipment blank data indicate no significant impact to target metal concentrations in soils occurred from external sources of contamination.

Field duplicate samples were also collected and analyzed. Duplicate vapor samples were generated at a 20 percent rate. As summarized in the soil vapor data review reports (Appendix G), average relative percent differences (RPDs) ranged from 6 to 14 percent, and were generally well below 10 percent for the most commonly detected contaminants. There is very good general agreement between duplicate pairs and good consistency between sampling rounds. This suggests that a consistent field sampling procedure, with reproducible results, is being properly implemented. Expanding the observed RPD range by two standard deviations indicates that the probability of significant variability (greater than 30 percent RPD) is about 1 in 100 (1 percent). The field duplicate data demonstrate a high level of precision associated with field sampling and laboratory analysis.

The project objective of generating 5 percent field duplicate samples was achieved by preparing and analyzing eight field duplicates during the course of collecting 163 environmental soil and test pit samples. Field duplicate data were used to assess the net precision associated with sample collection and laboratory analysis. A comparison of the target analyte data from the eight duplicate pairs demonstrates good agreement. No discrepancies were noted in the organic data set. As for metals, some RPDs exceeded the desired ± 30 percent RPD specified in EPA CLP guidance documents. However, the overall RPD summary for the inorganic analytes indicates 91 percent of the RPD values derived from field duplicate data were within the acceptable range. In this case, field duplicate data indicate an acceptable level of precision associated with field sampling and analyses performed for this investigation.

4.4.3 Analytical Methods and Laboratory Quality Assurance/Quality Control

All soil-vapor samples were analyzed for a list of 25 target VOC contaminants by EPA Method 8010/8020, which was modified for on-site mobile laboratory use. The Shimadzu 14A gas chromatograph with photo-ionization and electrolytic conductivity detectors underwent a three-point initial calibration followed by a daily set of calibration check standards (opening, LCS and closing). Laboratory QC data generated by TEG's instrumentation indicate that their on-site analytical system was in control during investigative testing.

Off-site analyses on samples VPSS-1 through VPSS-129 were performed by Analytical Technologies, Inc., at their San Diego facility. The analysis of samples VPSS-130 through 165 was performed by Intertek Testing Services of San Jose, California. In an additional test pit resampling event on June 10, 1999, two soil samples from each of the three test pits were resampled (VPSS-166 through VPSS-171) and sent to Quanterra Incorporated in West Sacramento, California. With the exception of the tributyltin and hexavalent chromium analyses, which were subcontracted to West Coast Analytical Service, Inc. of Santa Fe Springs, California, all resample analyses were performed by Quanterra Incorporated. A summary of the methods employed for the soil/test pit samples analyzed during this investigation is presented in Table 4-3. Information on types of containers, preservation and maximum holding times is provided in Table 4-4. Note that Intertek sent sample aliquots to their ITS sister facility in Colchester, Vermont for the tributyltin and PAH (SW-846 Method 8310) analysis. Dioxin testing (SW-846 Method 8280) is performed under a subcontract between ITS and Triangle Labs of Durham, North Carolina, except for the resampled test pits, which were analyzed for dioxins and furans at Quanterra Incorporated.

Along with the environmental and field QC samples submitted from the site, each laboratory also analyzed the required suite of internal QC samples (initial calibration, verification check standards, surrogate spikes, replicates, MS/MSD samples, laboratory control samples, method blanks, etc.) as appropriate for the published method of analysis. As indicated in Foster Wheeler's data evaluation summary reports, data generated from internal control samples were reviewed and evaluated during the data evaluation process after which data qualifiers were applied to the final data summaries as deemed necessary by the evaluators.

4.4.4 Data Validation

All of the analytical data reported for this investigation has undergone a three-tiered review process to assure that the information is of a known level of quality. Before these data were reported, they were reviewed by the laboratory performing the work and, in addition, at least two subsequent reviews were conducted to assure three-tiered validation. Analytical data from all of the soil samples, including those collected from test pits, and the equipment rinse blanks generated during soil sampling underwent formal "CLP-like" validation by Laboratory Data Consultants (LDC), a company located in Carlsbad, California, specializing in providing CLP data services. A subcontractor to JPL, LDC performed data validation independently from Foster Wheeler. After LDC reported their findings, Foster Wheeler had the data reports and

validation findings reviewed for a third time and summarized by a senior chemist from Foster Wheeler. Final data qualifiers were applied to the data set at that time. In addition, laboratory audits were performed at ATI and ITS. No significant issues were identified that would be expected to affect the quality or use of the RI analytical data generated by the subcontractor laboratories

Soils data validation was performed in accordance with the following documents as applicable to each analytical method:

- EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, February, 1994 (EPA, 1994a).
- EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, February, 1994 (EPA, 1994b).
- EPA SW-846 Test Methods for Evaluating Solid Waste, Third Edition, 1986a and subsequent revisions (EPA, 1996).
- JPL RI/FS, Quality Assurance Program for Performing a Remedial Investigation for the National Aeronautics and Jet Propulsion Laboratory, December, 1993 (Ebasco, 1993e).

Validation criteria for the following data requirements were assessed:

- Sample holding times
- GC/MS instrument performance checks
- Initial calibration results
- Calibration verification results
- Laboratory method blank results
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate results
- Laboratory control sample results
- ICP interference check sample results (metals)
- Atomic adsorption QC sample results
- Internal standard recoveries
- Target compound identification protocol
- Compound quantitation and reporting limits
- Tentatively identified compounds
- Overall system performance (extraction, analysis, reporting)
- Field-generated control sample results

Upon completion of the three-tiered data validation process, appropriate data qualifiers and comment codes were applied to the final report as warranted. These data qualifiers correlate certain outlying criteria to samples. The reason for the qualification may be further explained by one or more comment codes. Validation codes enable users to take action according to qualified data. Qualifiers used included U, J, UJ, and R as follows:

- U — The material was analyzed for, but not detected. The associated numerical value is the sample detection limit or adjusted sample detection limit.
- J — The associated numerical value is an estimated quantity because the reported concentrations were less than the required detection limits or quality control criteria were not met.
- UJ — The material was analyzed for, but not detected. The reported detection is estimated because quality control criteria were not met.
- R — The sample results are rejected (analyte may or may not be present) due to gross deficiencies in quality control criteria. Any reported value is unusable. Resampling and/or reanalysis is necessary for verification.

These same qualifier codes were used (as appropriate) during review of the soil vapor data packages. However, the validation criteria for soil-vapor samples were modified because there are no formal Contract Laboratory Program (CLP) procedures for evaluating soil-vapor data. Therefore, sufficient soil-vapor data were collected to complete a "CLP-like" evaluation of the soil vapor analytical results. The laboratory's external calibration and internal control sample results were summarized in tables along with copies of the individual chromatograms which were scrutinized by a Foster Wheeler senior chemist who reviewed the completed laboratory data packages in order to complete the three-tiered review process.

Foster Wheeler's review of soil-vapor data was performed to assess and evaluate adherence to the QA/QC and reporting requirements for soil gas investigation, protocols established by the California Regional Water Quality Control Board - Los Angeles Region, and general quality control requirements and good laboratory practices contained in the current reference methods (8000B & 8021) published in *Test Methods for Evaluating Solid Wastes - Physical/Chemical Methods*, SW-846, Office of Solid Waste and Emergency Response, EPA, Washington, DC, 3rd Edition, September 1986a (including Update IIB, January 1995).

There are some constraints imposed by the nature of any vapor matrix, which limit the types of control samples that can be run. These limits, and their potential impact on data reliability, are discussed in the soil vapor data evaluation reports in Appendix G.

4.4.5 Data Quality Assessment - Soils

After applying the RI soil data validation procedures established for assessment of target analyte results, approximately 3 percent of soil data were rejected (R-qualified). The great majority of these rejections were due to expiration of holding times, especially for the first set of test pit samples. Aside from holding time violations, the proportion of rejected data was very small (less

than 0.3 percent) and was due mostly to some antimony and silver results for which percent recoveries calculated from matrix spike control samples were exceptionally low. A replacement round of test pit sampling was performed (samples VPSS-166 through VPSS-171) and, aside from two acetone values, acceptable data were generated. Therefore, all but approximately 0.3 percent of the data reported and validated under this scope of work can be used in the remedial investigation. These rare circumstances of rejected data do not significantly impact the overall validity of the RI data set.

For the metals data set (including hexavalent chromium and total cyanide), an assessment was made to determine compliance with established guidelines for analytical precision and accuracy. It was found that, due to quality control deficiencies, less than 2 percent of all positively detected values required qualification as an estimated value (J-qualified). With regard to chromium, the primary metal of interest, 15 percent of all hexavalent chromium results received a J-flag, mostly because of calculation errors, while 8 percent of the total chromium data were J-qualified, mostly because of variation in lab duplicate results. In general, most metals results that were J-qualified were considered estimated values based on the following typical validation findings:

- The Relative Percent Difference (RPD) calculated from replicate preparation and analysis of the same soil sample was outside of recommended control limits.
- Serial dilutions analyzed by ion-coupled plasma (ICP) indicated the presence of matrix interference effects that were outside recommended control limits.
- Recoveries of matrix-spiked samples were not within recommended control limits.

An additional 4 percent of metals data were non-detect (U) results where the detection limit was estimated (UJ-qualified). This data quality flag was applied based on one or a combination of the following general validation findings:

- Matrix spike recoveries were not within recommended control limits.
- Target metals were detected in the laboratory blank at concentrations sufficient to question their presence at trace quantities in soil samples.
- The cyanide calibration check standard was not within the control limit recommended by the method protocol.

For the purposes of this investigation, it should be noted that data with a UJ qualification still provide useful information with respect to satisfying the project data quality objectives. Overall, the metals and cyanide data sets achieved the quality objectives developed for the RI.

In assessing the degree to which established guidelines for precision and accuracy were achieved for the target semi-volatile organic analytes, it was determined that the results from only a single sample should be rejected (R-qualified). This affected all target SVOC analytes for the one sample (VPSS-147) because the laboratory extracted the sample well past the holding time criterion. In addition, three benzidine results were rejected due to calibration problems. The rejected data rate was less than 1 percent of the total SVOC data.

Because the vast majority of the SVOC data (greater than 98 percent) was nondetect, most all qualified SVOC data received the UJ-flag, indicating that there was no target analyte detected but the reported detection limit was estimated. Approximately 20 percent of the total number of SVOC analyses received the UJ-flag, which was applied based on one, or a combination, of the following general validation findings listed in the descending order of frequency of occurrence:

- The percent recovery of the surrogate standard(s) for a particular fraction of the target SVOC compounds was not within acceptable control limits.
- Analyte-specific instrument response factors exhibited variability to the extent that the calculated percent differences between initial and continuing calibrations exceeded control limits.
- During initial calibration, response factor variability was observed such that calculated relative standard deviations among repetitive standardizations of a particular target SVOC exceeded control limits.
- The initial calibration curve did not exhibit acceptable linearity.

It should be noted that, for the purposes of this investigation, data with a UJ qualification still provide useful information with respect to satisfying the project data quality objectives. Overall, the SVOC data set achieved the quality objectives developed for the RI.

4.4.6 Data Quality Assessment – Soil-Vapor Samples

None of the data from soil-vapor samples was rejected as a result of the RI data review and validation process. Qualifications to the soil-vapor data set were made for the following three reasons:

1. If a particular target VOC result was reported at a concentration that was above the reporting range for the GC instrument, it was expected that the analyst would reanalyze a smaller aliquot volume from that sample. In accordance with RWQCB guidance, upper instrument reporting ranges were established at 150 percent of the highest calibration standard. Typically, the laboratory calibrated their instrument with a high standard at 100 µg/L. When a sample VOC concentration exceeded 150 µg/L on a 1 µL injection, reanalysis was required.

If no reanalysis was reported, the concentration originally calculated for that sample was considered to be an extrapolated value carried outside the working range of the initial calibration curve. Therefore, the affected data were qualified with a J, indicating that the analyte was positively identified, but that the associated result is approximate.

Of 3,150 soil vapor data values, there were 14 instances where a soil vapor VOC concentration exceeded the highest calibration standard by more than 150 percent, but the sample was not re-analyzed using a smaller aliquot that brought the raw instrumental result down within the working calibration range of the GC.

2. If an analyte-specific response factor derived from any QC check standard (a.m./p.m., continuing calibration, or laboratory control sample) was not within ± 20 percent of the average response factor (RF) used to calculate final results for that analyte (± 30 percent for the Freons, chloroethane and vinyl chloride), the associated soil-vapor data were subject to qualification as follows:
 - If the trend was toward decreasing sensitivity (check standard RF less than the average RF from the initial calibration curve), then detects and non-detects were qualified J, as estimated positive values or detection limits.
 - If the trend was toward increasing sensitivity (check standard RF greater than the average RF from initial calibration), then only positive results were qualified J, as estimated. In this case, non-detects were not qualified.

Based on this set of criteria, there were 47 results which were qualified J to indicate estimated values because a corresponding RF was not within control limits.

3. There were a few instances in which one sample of a field duplicate pair had a small but detectable (greater than 1 $\mu\text{g/L}$ -vapor) concentration of a target analyte, but that analyte was not detected in the other sample. In such cases, the positive result was qualified J, as estimated. This situation occurred for seven samples.

In all, approximately 2 percent of the data were qualified as estimated. However, it should be noted that, for the purposes of this RI, these extrapolated data still provide useful information, albeit with some lesser degree of precision and accuracy. Overall, the assessment of soil vapor and corresponding control sample data indicates that RI data quality objectives were achieved in terms of precision, accuracy, representativeness, comparability, and completeness for all analytes sampled.

4.4.7 Data Usability

Review of the QC data associated with soils (including test pit samples) and soil-vapor samples indicates project measurement data are compliant with respect to precision, accuracy, reasonability, comparability and completeness criteria limits and expectations. The quality of the data set fulfills project DQO's. Based on the data validation process, it was determined that less than 1 percent of the data was rejected as unusable. Acceptable but qualified data amount to less than 10 percent of the total. Depending on the reason for qualification, much of these data can be used for the purposes of this investigation. Overall, precision and accuracy for the RI analytical data set are acceptable and valid conclusions may be drawn from the soils and soil vapor sample results. Comparability is assured by carefully following the standard procedures for collecting, handling, extracting, analyzing, and reporting the data set developed for this project. The data completeness objective of 95 percent or better was accomplished for the Remedial Investigation.

4.5 SUMMARY OF THE NATURE AND EXTENT OF CONTAMINATION

A summary of the findings of the OU-2 RI with regard to compounds detected at JPL in soil and soil vapor are presented in this section.

4.5.1 Summary of Soil-Vapor Analyses

Results from the soil vapor sampling program indicate that VOCs are present in the soil vapor beneath JPL. The data indicate that chlorinated aliphatic compounds and chlorofluorocarbons are the main compounds of potential concern. Four compounds (CCl_4 , TCE, Freon 113, and 1,1-DCE) were consistently present at elevated concentrations, and of these, CCl_4 was the most frequently detected compound. The majority of VOC contamination was found beneath the central and eastern portions of the site at depths ranging from 20 feet to groundwater, and the concentrations increased with depth in most locations. The majority of contamination appears to be related to identified seepage pits, waste pits, and disposal areas.

There are no apparent lithologic factors that have controlled the lateral and vertical distribution of VOC vapors measured during the soil vapor sampling events. Because of the overall coarse-grained nature of the subsurface materials, even though they are interbedded and lenticular, the vapors appear to have freedom of movement in all directions, especially vertically downward and horizontally. The large areal distribution of the VOC vapors has probably been greatly influenced by the rapid and large fluctuations of the groundwater table that tends to spread the vapors horizontally with relative ease. This probability has been reinforced by the extraordinarily large radius of influence observed during an ongoing soil vapor extraction pilot test in the vicinity of soil vapor well Nos. 25, 26, 27, and 28.

4.5.2 Summary of Soil Analyses

A number of non-naturally occurring analytes were detected in surface (0 to 2 feet) and subsurface (below a depth of 2 feet) soil samples, including SVOCs, PAHs, PCBs, dioxin, VOCs, CN^- , Cr(VI) , tributyltin, and TPH. These compounds were generally detected in areas associated with past waste disposal activities. In addition, naturally occurring compounds or elements including As and NO_3^- were also detected. All elements included in the suite of Title 26 Metals, plus strontium and hexavalent chromium, were detected in JPL soils with the exception of selenium. Where detected, metal concentrations were reasonably well correlated within the range of background levels measured for JPL soils. Arsenic was detected in all but two soil samples collected at JPL and, as discussed in Section 4.3.2, may be elevated over the measured background values at several locations. Furans were not detected in any of the soil samples collected at JPL during the OU-2 RI field program.

Surface Soil

Four SVOCs (excluding PAHs) were detected in surface-soil samples collected from TP-2 and TP-2A. These included di-n-butyl phthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and n-nitroso-di-N-propylamine. Polynuclear aromatic hydrocarbons were found in the test pits

along the southeast portion of the site that were associated with prior waste disposal activities. The compounds detected in surface soil from TP-2 and TP-2A were benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, benzo(a)anthracene. Benzo(a)pyrene and benzo(g,h,i)perylene were detected in TP-3. The polychlorinated biphenyls, Arochlor-1254 and Arochlor-1260 were detected only in TP-2, and one dioxin congener (1,2,3,4,6,7,8,9-OCDD) was also detected in TP-2. Acetone, bromodichloromethane, chloroform, and methylene chloride were detected in three samples collected from the test pits at concentrations less than the reporting limit. Hexavalent chromium, which is generally not considered to occur naturally, was also detected at very low concentrations (less than 1 mg/kg) in TP-1A, TP-2A, and TP-3A. Nitrate, which is believed to have originated from agricultural and landscaping fertilizers, equestrian activities, and irrigation waters, was detected in all of the surface-soil samples. Tributyltin was detected at the detection limit of 1 µg/kg at a depth of 1 foot in TP-2A.

Subsurface Soil

Bis(2-ethylhexyl)phthalate was detected in seven soil borings at depths of 30 feet (one sample) or greater in subsurface soil at JPL, and polynuclear aromatic hydrocarbons were detected in two soil borings at depths of 10 feet in the southeastern portion of the site. The PAH compounds detected were fluoranthene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(g,h,i)perylene. Only one subsurface-soil sample collected at JPL contained a PCB, Arochlor-1232, which was from TP-1A. Similarly, tributyltin was detected at the detection limit of 1 µg/kg at the depth of 5 feet in TP-2A. Acetone, bromodichloromethane, chloroform, and methylene chloride were detected in soil samples collected from the test pits at concentrations equal to or less than the reporting limit. TPH, believed to have originated as lubricating or mineral oils, were detected in 13 soil borings; in another boring, the TPH detection is attributed to asphalt granules contained in backfill materials used to fill a seepage pit (cesspool). Hexavalent chromium was detected in one soil boring and three test pits. Nitrate, believed to have originated from agricultural and landscaping fertilizers, irrigation waters, equestrian activities, and cesspools, was detected in most of the soil borings and all of the test pits.

TABLE 4-1
DETAILS OF SAMPLING POINTS

Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
1	Soil Boring	8/30/94	8/30/94	Percussion Hammer	38	10	1124.5	1114.5	Soil Boring Converted to Vapor Well
						21		1103.5	
						33		1091.5	
2	Soil Boring	8/30/94	8/30/94	Percussion Hammer	38.5	10	1126.2	1116.2	Soil Boring Converted to Vapor Well
						22		1104.2	
						37		1089.2	
3	Soil Boring	9/1/94	9/1/94	Percussion Hammer	52	16	1133.9	1117.9	Soil Boring Converted to Vapor Well
						29		1104.9	
						40		1093.9	
						47		1086.9	
4	Soil Boring	9/2/94	9/2/94	Percussion Hammer	60.5	11	1137.6	1126.6	Soil Boring Converted to Vapor Well
						20		1117.6	
						35		1102.6	
						56		1081.6	
5	Soil Boring	9/3/94	9/3/94	Percussion Hammer	12	2	1126.8	1124.8	Soil Boring Converted to Vapor Well
						5		1121.8	
						9		1117.8	
6	Soil Boring	9/6/94	9/6/94	Percussion Hammer	100.5	20	1137.5	1117.5	Soil Boring Converted to Vapor Well
						40		1097.5	
						60		1077.5	
						77		1060.5	
						96		1041.5	
7	Soil Boring	9/8/94	9/8/94	Percussion Hammer	60.5	20	1115.8	1095.8	Soil Boring Converted to Vapor Well
						35		1080.8	
8	Soil Boring	9/9/94	9/9/94	Percussion Hammer	101.5	20	1256.6	1236.6	Soil Boring Converted to Vapor Well
						30		1226.6	
						50		1206.6	
						70		1186.6	
						90		1166.6	

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Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
9	Soil Boring	9/10/94	9/11/94	Percussion Hammer	90	20	1230.8	1210.8	Soil Boring Converted to Vapor Well
						35		1195.8	
						50		1180.8	
						70		1160.8	
						87		1143.8	
10	Soil Boring	9/13/94	9/13/94	Percussion Hammer	72	20	1232.8	1212.8	Soil Boring Converted to Vapor Well
						35		1197.8	
						50		1182.8	
						69		1163.8	
11	Soil Boring	9/17/94	9/18/94	Percussion Hammer	100	20	1193.1	1173.1	Soil Boring Converted to Vapor Well
						40		1153.1	
						60		1133.1	
						80		1113.1	
						96		1097.1	
12	Soil Boring	9/19/94	9/19/94	Percussion Hammer	81	20	1097.9	1077.9	Soil Boring Converted to Vapor Well
						40		1057.9	
						60		1037.9	
						76		1021.9	
13	Soil Boring	9/20/94	9/21/94	Percussion Hammer	48	10	1239.2	1229.2	Soil Boring Converted to Vapor Well
						20		1219.2	
						30		1209.2	
						40		1199.2	
14	Soil Boring	9/22/94	9/22/94	Percussion Hammer	18	5	1213.0	1208.0	Soil Boring Converted to Vapor Well
						10		1203.0	
						13		1200.0	
15	Soil Boring	9/24/94	9/24/94	Percussion Hammer	95	20	1123.5	1103.5	Soil Boring Converted to Vapor Well
						40		1083.5	
						60		1063.5	
						75		1048.5	
						90		1033.5	

TABLE 4-1
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Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
16	Soil Boring	9/29/94	9/29/94	Percussion Hammer	101.5	20	1199.2	1179.2	Soil Boring Converted to Vapor Well
						40		1159.2	
						60		1139.2	
						80		1119.2	
						95		1104.2	
17	Soil Boring	9/30/94	9/30/94	Percussion Hammer	40	12	1214.1	1202.1	Soil Boring Converted to Vapor Well
						24		1190.1	
						36		1178.1	
18	Soil Boring	10/2/94	10/2/94	Percussion Hammer	89.5	20	1109.4	1089.4	Soil Boring Converted to Vapor Well
						40		1069.4	
						55		1054.4	
						70		1039.4	
						85		1024.4	
19	Soil Boring	10/3/94	N/A	Percussion Hammer	46	N/A	1196.3	N/A	Soil Boring Only
19A	Soil Boring	10/4/94	10/4/94	Percussion Hammer	101	20	1196.4	1176.4	Soil Boring Converted to Vapor Well
						40		1156.4	
						60		1136.4	
						80		1116.4	
						96		1100.4	
20	Soil Boring	10/13/94	10/13/94	Percussion Hammer	41.5	10	1142.7	1132.7	Soil Boring Converted to Vapor Well
						20		1122.7	
						30		1112.7	
						37		1105.7	
20A	Soil Boring	10/23/94	10/23/94	Percussion Hammer	72	20	1142.7	1122.7	Soil Boring Converted to Vapor Well
						30		1112.7	
						47		1095.7	
						60		1082.7	

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Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
21	Soil Boring	10/9/94	10/9/94	Percussion Hammer	90	20	1127.1	1107.1	Soil Boring Converted to Vapor Well
						40		1087.1	
						55		1072.1	
						70		1057.1	
						85		1042.1	
22	Soil Boring	10/12/94	10/12/94	Percussion Hammer	100.5	20	1129.0	1109.0	Soil Boring Converted to Vapor Well
						40		1089.0	
						60		1069.0	
						80		1049.0	
						95		1034.0	
23	Soil Boring	10/17/94	N/A	Percussion Hammer	20.5	N/A	1094.6	N/A	Soil Boring Only
23A	Soil Boring	10/18/94	N/A	Percussion Hammer	26.5	N/A	1094.8	N/A	Soil Boring Only
23B	Soil Boring	10/18/94	10/18/94	Percussion Hammer	21	5	1094.9	1089.9	Soil Boring Converted to Vapor Well
						11		1083.9	
						17		1077.9	
24	Soil Boring	10/15/94	10/16/94	Percussion Hammer	100	20	1125.0	1105.0	Soil Boring Converted to Vapor Well
						40		1085.0	
						60		1065.0	
						80		1045.0	
						95		1030.0	
25	Soil-Vapor Well	3/31/97	3/31/97	Sonic	202	20	1199.6	1179.6	Deep Soil-Vapor Well
						40		1159.6	
						60		1139.6	
						85		1114.6	
						100		1099.6	
						120		1079.6	
						145		1054.6	
						165		1034.6	
						180		1019.6	
						190		1009.6	

TABLE 4-1
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Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
26	Soil-Vapor Well	3/27/97	3/28/97	Sonic	206	20	1201.8	1181.8	Deep Soil-Vapor Well
						35		1166.8	
						55		1146.8	
						80		1121.8	
						100		1101.8	
						115		1086.8	
						140		1061.8	
						160		1041.8	
						180		1021.8	
						195		1006.8	
27	Soil-Vapor Well	3/18/97	3/18/97	Sonic	214	20	1214.2	1194.2	Deep Soil-Vapor Well
						35		1179.2	
						60		1154.2	
						85		1129.2	
						100		1114.2	
						120		1094.2	
						140		1074.2	
						160		1054.2	
						180		1034.2	
						205		1009.2	
28	Soil-Vapor Well	3/13/97	3/14/97	Sonic	179	20	1176.7	1156.7	Deep Soil-Vapor Well
						45		1131.7	
						65		1111.7	
						80		1096.7	
						105		1071.7	
						120		1056.7	
						140		1036.7	
						160		1016.7	

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Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
29	Soil Boring	4/12/97	4/12/97	Sonic	83	20	1086.8	1066.8	Soil Boring Converted to Vapor Well
						35		1051.8	
						50		1036.8	
						60		1026.8	
						78		1008.8	
30	Soil Boring	4/2/97	4/2/97	Sonic	72	17	1088.9	1071.9	Soil Boring Converted to Vapor Well
						30		1058.9	
						40		1048.9	
						50		1038.9	
						65		1023.9	
31	Soil Boring	4/9/97	4/9/97	Sonic	73	20	1083.1	1063.1	Soil Boring Converted to Vapor Well
						35		1048.1	
						45		1038.1	
						55		1028.1	
						65		1018.1	
32	Soil-Vapor Well	3/29/98	3/29/98	Sonic	210	25	1206.6	1181.6	Deep Soil-Vapor Well
						40		1166.6	
						55		1151.6	
						70		1136.6	
						90		1116.6	
						115		1091.6	
						135		1071.6	
						155		1051.6	
						180		1026.6	
						195		1011.6	

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DETAILS OF SAMPLING POINTS

Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
33	Soil-Vapor Well	3/31/98	4/1/98	Sonic	213	20	1214.0	1194.0	Deep Soil-Vapor Well
						40		1174.0	
						60		1154.0	
						85		1129.0	
						105		1109.0	
						120		1094.0	
						140		1074.0	
						160		1054.0	
						180		1034.0	
						200		1014.0	
34	Soil-Vapor Well	4/8/98	4/8/98	Sonic	135	20	1164.3	1144.3	Deep Soil-Vapor Well
						35		1129.3	
						50		1114.3	
						65		1099.3	
						80		1084.3	
						95		1069.3	
						108		1056.3	
						118		1046.3	
35	Soil-Vapor Well	4/14/98	4/14/98	Sonic	162.5	20	1183.2	1163.2	Deep Soil-Vapor Well
						35		1148.2	
						50		1133.2	
						60		1123.2	
						80		1103.2	
						95		1088.2	
						110		1073.2	
						125		1058.2	
						140		1043.2	
						155		1028.2	

TABLE 4-1
DETAILS OF SAMPLING POINTS

Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
36	Soil-Vapor Well	3/27/98	3/27/98	Sonic	117	20	1232.8	1212.8	Deep Soil-Vapor Well
						35		1197.8	
						55		1177.8	
						75		1157.8	
						92		1140.8	
37	Soil-Vapor Well	4/7/98	4/7/98	Sonic	193	25	1195.7	1170.7	Deep Soil-Vapor Well
						40		1155.7	
						60		1135.7	
						80		1115.7	
						100		1095.7	
						120		1075.7	
						140		1055.7	
						155		1040.7	
						170		1025.7	
38	Soil-Vapor Well	4/15/98	4/15/98	Sonic	178.5	185	1185.6	1010.7	Deep Soil-Vapor Well
						25		1160.6	
						45		1140.6	
						65		1120.6	
						80		1105.6	
						95		1090.6	
						110		1075.6	
						125		1060.6	
						140		1045.6	
						155		1030.6	
						170		1015.6	

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Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
39	Soil-Vapor Well	4/17/98	4/17/98	Sonic	138	20	1144.1	1124.1	Deep Soil-Vapor Well
						35		1109.1	
						50		1094.1	
						70		1074.1	
						85		1059.1	
						100		1044.1	
						110		1034.1	
						120		1024.1	
						130		1014.1	
BG-1	Soil Boring	4/6/94	N/A	Hollow Stem Auger	25	N/A	1190.7	N/A	Soil Boring Only
BG-1A	Soil Boring	10/1/94	N/A	Hollow Stem Auger	21	N/A	1190.7	N/A	Soil Boring Only
BG-2	Soil Boring	4/6/94	N/A	Hollow Stem Auger	18	N/A	1265.2	N/A	Soil Boring Only
BG-2A	Soil Boring	10/1/94	N/A	Hollow Stem Auger	18	N/A	1265.2	N/A	Soil Boring Only
SV-1	Soil-Vapor Probe	N/A	1/14/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-2	Soil-Vapor Probe	N/A	1/14/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-3	Soil-Vapor Probe	N/A	1/14/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-4	Soil-Vapor Probe	N/A	1/14/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-5	Soil-Vapor Probe	N/A	1/14/94	Direct Push	22	22	N/A	N/A	Installed for Screening Purposes Only
SV-7	Soil-Vapor Probe	N/A	1/15/94	Direct Push	12	12	N/A	N/A	Installed for Screening Purposes Only
SV-8	Soil-Vapor Probe	N/A	1/15/94	Direct Push	12	12	N/A	N/A	Installed for Screening Purposes Only
SV-9	Soil-Vapor Probe	N/A	1/15/94	Direct Push	19	19	N/A	N/A	Installed for Screening Purposes Only
SV-10	Soil-Vapor Probe	N/A	1/15/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-11	Soil-Vapor Probe	N/A	1/15/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-13	Soil-Vapor Probe	N/A	1/15/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-14	Soil-Vapor Probe	N/A	1/15/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-15	Soil-Vapor Probe	N/A	1/15/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-16	Soil-Vapor Probe	N/A	1/15/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-17	Soil-Vapor Probe	N/A	1/15/94	Direct Push	11	11	N/A	N/A	Installed for Screening Purposes Only
SV-19	Soil-Vapor Probe	N/A	1/15/94	Direct Push	19	19	N/A	N/A	Installed for Screening Purposes Only

TABLE 4-1
DETAILS OF SAMPLING POINTS

Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
SV-20	Soil-Vapor Probe	N/A	1/15/94	Direct Push	19	19	N/A	N/A	Installed for Screening Purposes Only
SV-21	Soil-Vapor Probe	N/A	1/16/94	Direct Push	10	10	N/A	N/A	Installed for Screening Purposes Only
SV-22	Soil-Vapor Probe	N/A	1/16/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-23	Soil-Vapor Probe	N/A	1/16/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-25	Soil-Vapor Probe	N/A	1/16/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-26	Soil-Vapor Probe	N/A	1/16/94	Direct Push	14	14	N/A	N/A	Installed for Screening Purposes Only
SV-27	Soil-Vapor Probe	N/A	1/16/94	Direct Push	16	16	N/A	N/A	Installed for Screening Purposes Only
SV-28	Soil-Vapor Probe	N/A	1/16/94	Direct Push	9	9	N/A	N/A	Installed for Screening Purposes Only
SV-29	Soil-Vapor Probe	N/A	1/16/94	Direct Push	13	13	N/A	N/A	Installed for Screening Purposes Only
SV-31	Soil-Vapor Probe	N/A	1/16/94	Direct Push	13	13	N/A	N/A	Installed for Screening Purposes Only
SV-32	Soil-Vapor Probe	N/A	1/16/94	Direct Push	16	16	N/A	N/A	Installed for Screening Purposes Only
SV-33	Soil-Vapor Probe	N/A	1/16/94	Direct Push	11	11	N/A	N/A	Installed for Screening Purposes Only
SV-34	Soil-Vapor Probe	N/A	1/16/94	Direct Push	8	8	N/A	N/A	Installed for Screening Purposes Only
SV-35	Soil-Vapor Probe	N/A	1/16/94	Direct Push	13	13	N/A	N/A	Installed for Screening Purposes Only
SV-37	Soil-Vapor Probe	N/A	1/17/94	Direct Push	18	18	N/A	N/A	Installed for Screening Purposes Only
SV-38	Soil-Vapor Probe	N/A	1/17/94	Direct Push	12	12	N/A	N/A	Installed for Screening Purposes Only
SV-39	Soil-Vapor Probe	N/A	1/17/94	Direct Push	19	19	N/A	N/A	Installed for Screening Purposes Only
SV-40	Soil-Vapor Probe	N/A	1/17/94	Direct Push	19	19	N/A	N/A	Installed for Screening Purposes Only
SV-41	Soil-Vapor Probe	N/A	1/17/94	Direct Push	15	15	N/A	N/A	Installed for Screening Purposes Only
SV-43	Soil-Vapor Probe	N/A	1/17/94	Direct Push	17	17	N/A	N/A	Installed for Screening Purposes Only
SV-44	Soil-Vapor Probe	N/A	1/17/94	Direct Push	11	11	N/A	N/A	Installed for Screening Purposes Only
SV-45	Soil-Vapor Probe	N/A	1/17/94	Direct Push	10	10	N/A	N/A	Installed for Screening Purposes Only
SV-46	Soil-Vapor Probe	N/A	1/17/94	Direct Push	12	20	N/A	N/A	Installed for Screening Purposes Only
SV-47	Soil-Vapor Probe	N/A	1/17/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-49	Soil-Vapor Probe	N/A	1/18/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-50	Soil-Vapor Probe	N/A	1/18/94	Direct Push	20	20	N/A	N/A	Installed for Screening Purposes Only
SV-52	Soil-Vapor Probe	N/A	1/18/94	Direct Push	15	15	N/A	N/A	Installed for Screening Purposes Only
SV-53	Soil-Vapor Probe	N/A	1/18/94	Direct Push	11	11	N/A	N/A	Installed for Screening Purposes Only

TABLE 4-1
DETAILS OF SAMPLING POINTS

Boring/ Soil-Vapor Well/ Probe/Test Pit Number	Purpose	Date Drilling Completed	Date Vapor Well/ Probe Installed	Drilling Method	Boring Depth (ft bgs)	Depth to Sampling Tip (ft bgs)	Elevation of Ground Surface (ft amsl)	Elevation of Soil Vapor Sampling Tip (ft amsl)	Comments
SV-54	Soil-Vapor Probe	N/A	1/18/94	Direct Push	8	8	N/A	N/A	Installed for Screening Purposes Only
SV-55	Soil-Vapor Probe	N/A	1/18/94	Direct Push	6	6	N/A	N/A	Installed for Screening Purposes Only
SV-57	Soil-Vapor Probe	N/A	1/18/94	Direct Push	17	17	N/A	N/A	Installed for Screening Purposes Only
SV-58	Soil-Vapor Probe	N/A	1/18/94	Direct Push	6	6	N/A	N/A	Installed for Screening Purposes Only
TP-1	Test Pit	4/14/97	N/A	Backhoe	6	N/A	1058.5	N/A	Trenches Completed near Surface Drainage Outfalls
TP-2	Test Pit	4/14/97	N/A	Backhoe	6	N/A	1094.4	N/A	Trenches Completed near Surface Drainage Outfalls
TP-3	Test Pit	4/14/97	N/A	Backhoe	6	N/A	1097.2	N/A	Trenches Completed near Surface Drainage Outfalls
TP-1A	Test Pit	6/10/99	N/A	Backhoe	6	N/A	1097.0	N/A	Trenches Completed near Surface Drainage Outfalls
TP-2A	Test Pit	6/10/99	N/A	Backhoe	6	N/A	1094.4	N/A	Trenches Completed near Surface Drainage Outfalls
TP-3A	Test Pit	6/10/99	N/A	Backhoe	6	N/A	1058.3	N/A	Trenches Completed near Surface Drainage Outfalls

Notes:

- amsl - Above mean sea level.
- BG - Background samples.
- bgs - Below ground surface.
- N/A - Not applicable.
- SV - Soil vapor.
- TP - Test pit.

TABLE 4-2
SUMMARY OF SOIL VAPOR SAMPLING EVENTS
 (Dates indicate the days sampling took place)

Probe/Soil Vapor Well Number	Event 1 Jan-94	Event 2 Dec-94	Event 3 Mar-95	Event 4 Jun-97	Event 5 Jul-97	Event 6 May-98	Event 7 Jun-98
SV-1 through SV-58	1/14-1/18	NS	NS	NS	NS	NS	NS
Nos. 1 through 24	NI	12/20 – 12/29 ^{1,2}	3/7 – 3/10	NS	NS	NS	NS
Nos. 25 through 31	NI	NI	NI	6/23 – 6/26 ^{1,3}	7/21 – 7/24	NS	NS
Nos. 25 through 28, Nos. 32 through 39	NI	NI	NI	NI	NI	5/18 – 5/22	NS
Nos. 32 through 39	NI	NI	NI	NI	NI	NI	6/15 – 6/19

Notes:

¹ Soil samples were collected for analysis during drilling, prior to conversion of borings to soil-vapor wells (see Table 4-1).

² Background soil samples were collected during drilling for metals analyses.

³ Test pit samples were collected and analyzed.

NI - Not installed.

NS - Not sampled.

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

				Analyses														
Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	Gross Alpha/ Gross Beta
1	20	8/29/94	VPSS-1	x	x						x	x	x		x	x	x	
1	37	8/29/94	VPSS-2	x	x						x	x	x		x	x	x	
2	10	8/30/94	VPSS-3	x	x						x	x	x		x	x	x	
2	38	8/30/94	VPSS-4	x											x	x		
3	30	9/1/94	VPSS-5	x	x						x	x	x		x	x	x	
3	50	9/1/94	VPSS-6	x											x	x	x	
4	10	9/2/94	VPSS-7	x	x						x	x	x		x	x	x	
4	20	9/2/94	VPSS-8	x											x	x	x	
4	35	9/2/94	VPSS-9	x	x						x	x	x		x	x	x	
4	40	9/2/94	VPSS-10	x											x	x	x	
4	50	9/2/94	VPSS-11	x	x						x	x	x		x	x	x	
4	61	9/2/94	VPSS-12	x											x	x	x	
5	10	9/3/94	VPSS-13	x	x						x	x	x		x	x	x	
6	10	9/4/94	VPSS-14		x						x	x	x		x	x	x	
6	20	9/4/94	VPSS-15	x											x	x	x	
6	30	9/4/94	VPSS-16	x	x						x	x	x		x	x	x	
6	48.5	9/4/94	VPSS-17	x											x	x	x	
6	51	9/4/94	VPSS-18	x	x						x	x	x		x	x	x	
6	60.5	9/4/94	VPSS-19	x											x	x	x	
6	70	9/4/94	VPSS-20	x	x						x	x	x		x	x	x	
7	30	9/5/94	VPSS-21	x	x						x	x	x		x	x	x	
7	50	9/5/94	VPSS-22	x	x						x	x	x		x	x	x	
7	60	9/5/94	VPSS-23	x											x	x	x	
8	10	9/8/94	VPSS-24	x	x						x	x	x		x	x	x	
8	20	9/8/94	VPSS-25	x											x	x	x	
8	30	9/8/94	VPSS-26	x	x						x	x	x		x	x	x	
8	40	9/8/94	VPSS-27	x											x	x	x	

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Analyses														Gross Alpha/ Gross Beta
				Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
8	50	9/8/94	VPSS-28	x	x						x	x	x		x	x	x	
8	65	9/8/94	VPSS-29	x											x	x	x	
8	81	9/9/94	VPSS-30	x	x						x	x	x		x	x	x	
8	101	9/9/94	VPSS-31	x											x	x	x	
9	10	9/10/94	VPSS-32	x											x	x		
9	21(DUP)	9/10/94	VPSS-34	x	x						x	x	x		x	x	x	
9	21.5	9/10/94	VPSS-33	x	x						x	x	x		x	x	x	
9	40.5	9/10/94	VPSS-35	x											x	x		
9	48	9/10/94	VPSS-36	x	x						x	x	x		x	x	x	
9	51	9/10/94	VPSS-37	x											x	x		
9	60	9/10/94	VPSS-38	x	x						x	x	x		x	x	x	
9	80	9/10/94	VPSS-39	x											x	x	x	
10	11	9/12/94	VPSS-40	x											x	x	x	
10	20.5(DUP)	9/12/94	VPSS-42	x	x						x	x	x		x	x	x	
10	21	9/12/94	VPSS-41	x	x						x	x	x		x	x	x	
10	31	9/12/94	VPSS-43	x											x	x	x	
10	40.5	9/12/94	VPSS-44	x	x						x	x	x		x	x	x	
10	50.5	9/12/94	VPSS-45	x											x	x	x	
10	60.5	9/12/94	VPSS-46	x	x						x	x	x		x	x	x	
10	70.5	9/12/94	VPSS-47	x											x	x	x	
11	11	9/17/94	VPSS-48	x											x	x	x	
11	21	9/17/94	VPSS-49	x	x						x	x	x		x	x	x	
11	31	9/17/94	VPSS-50	x											x	x	x	
11	40.5	9/17/94	VPSS-52	x	x						x	x	x		x	x	x	
11	41	9/17/94	VPSS-51	x											x	x	x	
11	51	9/17/94	VPSS-53	x	x						x	x	x		x	x	x	
11	68.5	9/17/94	VPSS-54	x											x	x	x	

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Analyses														Gross Alpha/ Gross Beta
				Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
11	71	9/17/94	VPSS-55	x	x						x	x	x		x	x	x	
11	99.5	9/17/94	VPSS-57	x											x	x	x	
12	10	9/19/94	VPSS-58	x	x										x	x	x	
12	25.5	9/19/94	VPSS-59	x	x						x	x	x		x	x	x	
12	34	9/19/94	VPSS-60	x	x						x	x	x		x	x	x	
12	40.5	9/19/94	VPSS-61	x											x	x	x	
12	60.5	9/19/94	VPSS-62	x	x						x	x	x		x	x	x	
12	71	9/19/94	VPSS-63	x											x	x	x	
13	10.5	9/20/94	VPSS-64	x	x						x	x	x		x	x	x	
13	20.5	9/20/94	VPSS-65	x											x	x	x	
13	30.5	9/20/94	VPSS-66	x	x						x	x	x		x	x	x	
14	11	9/22/94	VPSS-67	x	x						x	x	x		x	x	x	
15	11	9/24/94	VPSS-68	x											x	x	x	
15	21	9/24/94	VPSS-69	x	x						x	x	x		x	x	x	
15	31	9/24/94	VPSS-70	x	x						x	x	x		x	x	x	
15	57	9/24/94	VPSS-71	x											x	x	x	
15	61	9/24/94	VPSS-72	x	x						x	x	x		x	x	x	
15	70	9/24/94	VPSS-73	x											x	x	x	
15	81	9/24/94	VPSS-74	x	x						x	x	x		x	x	x	
16	20.5(DUP)	9/28/94	VPSS-75	x	x						x	x	x		x	x	x	
16	21	9/28/94	VPSS-76	x	x						x	x	x		x	x	x	
16	31	9/28/94	VPSS-77	x											x	x	x	
16	41	9/28/94	VPSS-78	x	x						x	x	x		x	x	x	
16	50.5	9/28/94	VPSS-80	x											x	x	x	
16	51	9/28/94	VPSS-79	x											x	x	x	
16	61	9/28/94	VPSS-81	x	x						x	x	x		x	x	x	
16	71	9/28/94	VPSS-82	x											x	x	x	
16	81	9/28/94	VPSS-83	x	x						x	x	x		x	x	x	
16	91	9/28/94	VPSS-84	x											x	x	x	
16	101	9/28/94	VPSS-85	x							x	x	x		x	x	x	

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

				Analyses														
Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	Gross Alpha/ Gross Beta
17	20.5	9/30/94	VPSS-86	x											x	x	x	
17	26.5	9/30/94	VPSS-87	x	x						x	x	x		x	x	x	
18	10	10/1/94	VPSS-88	x	x						x	x	x		x	x	x	
18	34.5	10/1/94	VPSS-89	x	x						x	x	x		x	x	x	
18	45	10/1/94	VPSS-90	x											x	x	x	
18	50	10/1/94	VPSS-91	x	x						x	x	x		x	x	x	
18	60	10/1/94	VPSS-92	x											x	x	x	
18	70	10/1/94	VPSS-93	x	x						x	x	x		x	x	x	
19	10.5	10/3/94	VPSS-94	x	x						x	x	x		x	x	x	x
19	30.5	10/3/94	VPSS-95	x	x						x	x	x		x	x	x	x
19A	20.5	10/4/94	VPSS-96	x											x	x	x	
19A	40.5	10/4/94	VPSS-97	x											x	x	x	
19A	51	10/4/94	VPSS-98	x	x						x	x	x		x	x	x	x
19A	51(DUP)	10/4/94	VPSS-98															x
19A	61	10/4/94	VPSS-99	x											x	x	x	
19A	70.5	10/4/94	VPSS-100	x	x						x	x	x		x	x	x	x
19A	90.5	10/4/94	VPSS-101	x											x	x	x	
19A	100.5	10/4/94	VPSS-102	x											x	x	x	
20	11	10/13/94	VPSS-114	x											x	x	x	
20	21	10/13/94	VPSS-115	x	x						x	x	x		x	x	x	
20	31	10/13/94	VPSS-116	x	x						x	x	x		x	x	x	
20A	11	10/22/94	VPSS-125	x											x	x	x	
20A	20.5(DUP)	10/22/94	VPSS-126	x	x						x	x	x		x	x	x	
20A	21	10/22/94	VPSS-127	x	x						x	x	x		x	x	x	
20A	50	10/22/94	VPSS-128	x	x						x	x	x		x	x	x	
20A	71	10/22/94	VPSS-129	x	x						x	x	x		x	x	x	
21	9	10/8/94	VPSS-103	x											x	x	x	
21	19(DUP)	10/8/94	VPSS-104	x	x						x	x	x		x	x	x	

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Analyses														Gross Alpha/ Gross Beta
				Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	
21	19.5	10/8/94	VPSS-105	x	x						x	x	x		x	x	x	
21	29	10/8/94	VPSS-106	x											x	x	x	
21	49	10/9/94	VPSS-107	x	x						x	x	x		x	x	x	
21	59	10/9/94	VPSS-108	x	x						x	x	x		x	x	x	
22	11	10/11/94	VPSS-109	x											x	x	x	
22	20.5(DUP)	10/11/94	VPSS-110	x	x						x	x	x		x	x	x	
22	21	10/11/94	VPSS-111	x	x						x	x	x		x	x	x	
22	31	10/11/94	VPSS-112	x	x						x	x	x		x	x	x	
23	50.5	10/11/94	VPSS-113	x	x						x	x	x		x	x	x	
23A	1.5	10/18/94	VPSS-123	x	x						x	x	x		x	x	x	
23A	26	10/18/94	VPSS-124	x	x						x	x	x		x	x	x	
24	10	10/15/94	VPSS-117	x											x	x	x	
24	20	10/15/94	VPSS-118	x	x						x	x			x	x	x	
24	29.5	10/15/94	VPSS-119	x	x						x	x			x	x	x	
24	49.5	10/15/94	VPSS-120	x	x						x	x			x	x	x	
24	59.5	10/15/94	VPSS-121	x											x	x	x	
24	69.5	10/15/94	VPSS-122	x	x						x	x	x		x	x	x	
29	4	4/11/97	VPSS-148	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	7	4/11/97	VPSS-149	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	10	4/11/97	VPSS-150	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	15	4/11/97	VPSS-151	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	20	4/11/97	VPSS-152	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	20(DUP)	4/11/97	VPSS-153	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	30	4/11/97	VPSS-154	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	40	4/11/97	VPSS-155	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	49	4/12/97	VPSS-156	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	60	4/12/97	VPSS-157	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	70	4/12/97	VPSS-158	x	x		x	x	x	x	x	x	x	x	x	x	x	
29	79.5	4/12/97	VPSS-159	x	x		x	x	x	x	x	x	x	x	x	x	x	

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

				Analyses															
Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	Gross Alpha/ Gross Beta	
30	5	4/1/97	VPSS-130	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	10	4/1/97	VPSS-131	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	15	4/1/97	VPSS-132	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	20	4/1/97	VPSS-133	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	30	4/1/97	VPSS-134	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	40	4/2/97	VPSS-135	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	50	4/2/97	VPSS-136	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	60	4/2/97	VPSS-137	x	x		x	x	x	x	x	x	x	x	x	x	x		
30	69.5	4/2/97	VPSS-138	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	5	4/8/97	VPSS-139	x	x		x	x	x	x	x		x	x	x	x	x		
31	10	4/8/97	VPSS-140	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	15	4/8/97	VPSS-141	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	20	4/8/97	VPSS-142	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	30	4/8/97	VPSS-143	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	40	4/8/97	VPSS-144	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	50	4/8/97	VPSS-145	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	59.5	4/8/97	VPSS-146	x	x		x	x	x	x	x	x	x	x	x	x	x		
31	70	4/9/97	VPSS-147	x	x		x	x	x	x	x	x	x	x	x	x	x		
BG-1	25	10/1/94	SS-1	x															
BG-1A	20.5(DUP)	10/1/94	SS-3	x											x	x			
BG-1A	21	10/1/94	SS-4	x											x	x			
BG-2	18	10/1/94	SS-2	x															
BG-2A	18	10/1/94	SS-5	x											x	x			
TP-1	5	4/14/97	VPSS-160	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-1	2	4/14/97	VPSS-161	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-2	1	4/14/97	VPSS-162	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-2	5	4/14/97	VPSS-163	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-3	2	4/14/97	VPSS-164	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-3	5	4/14/97	VPSS-165	x	x	x	x	x	x	x		x	x	x	x	x	x		

TABLE 4-3

SUMMARY OF ANALYSES PERFORMED ON SOIL SAMPLES

				Analyses															
Boring/ Test Pit Number	Depth (ft bgs)	Date	Sample Number	Title 26 Metals	SVOCs	VOCs	PAHs	PCBs	Dioxins	Furans	TPH	Cyanide	Nitrates	Tributyltin	Total Solids	Percent Moisture	pH	Gross Alpha/ Gross Beta	
TP-1A	2	6/10/99	VPSS-166	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-1A	5	6/10/99	VPSS-167	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-2A	1	6/10/99	VPSS-168	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-2A	5	6/10/99	VPSS-169	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-3A	2	6/10/99	VPSS-170	x	x	x	x	x	x	x		x	x	x	x	x	x		
TP-3A	5	6/10/99	VPSS-171	x	x	x	x	x	x	x		x	x	x	x	x	X		

Notes:

- BG - Background samples.
- DUP - Duplicate samples.
- PAHs - Polynuclear Aromatic Hydrocarbons.
- PCBs - Polychlorinated Biphenyls.
- SVOCs - Semi-Volatile Organic Compounds.
- TPH - Total Petroleum Hydrocarbons.
- TP - Test pit.
- VOCs - Volatile Organic Compounds.

TABLE 4-4
SUMMARY OF EPA METHODS FOR ANALYSES
PERFORMED ON SOIL VAPOR AND SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
SOIL VAPOR					
Volatile Organic Compounds	8010/8020	Syringe	N/A	15 minutes	1.0 µg/L
Benzene					
Vinyl chloride					
Carbon tetrachloride					
1,2-Dichloroethane					
Trichloroethene					
1,1-Dichloroethene					
1,1,1-Trichloroethane					
Bromomethane					
Chloroethane					
Chloroform					
trans-1,2-Dichloroethene					
cis-1,2-Dichloroethene					
Dichloromethane					
1,1-Dichloroethane					
Ethyl benzene					
1,1,2-Trichloroethane					
1,1,1,2-Tetrachloroethane					
1,1,2,2-Tetrachloroethane					
Tetrachloroethylene					
Toluene					
m,p-Xylenes					
o-Xylene					
Fluorotrichloromethane (Freon 11)					
Dichlorodifluoromethane (Freon 12)					
Trichlorotrifluoroethane (Freon 113)					
SOIL					
Title 26 Metals + Strontium (Sr)	Various	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Variable	Variable*
Silver (Ag)	6010			6 months	
Arsenic (As)	206.2			6 months	
Barium (Ba)	6010			6 months	
Beryllium (Be)	6010			6 months	
Cadmium (Cd)	6010			6 months	
Chromium (Cr)	6010			6 months	
Cobalt (Co)	6010			6 months	
Copper (Cu)	6010			6 months	
Mercury (Hg)	245.1			28 days	
Molybdenum (Mo)	6010			6 months	
Nickel (Ni)	6010			6 months	
Lead (Pb)	239.2			6 months	
Antimony (Sb)	204.2			6 months	
Selenium (Se)	270.2			6 months	
Thallium (Tl)	279.2			6 months	
Vanadium (V)	6010			6 months	

TABLE 4-4
SUMMARY OF EPA METHODS FOR ANALYSES
PERFORMED ON SOIL VAPOR AND SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Strontium (Sr)	6010			6 months	
Zinc (Zn)	6010			6 months	
Chromium (Hexavalent)	7196	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	24 hours	Variable*
Cyanide	335.3	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	14 days	Variable*
Tributyltin	GC/FPD	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	35 days	Variable*
Total Petroleum Hydrocarbons	EPA 418.1	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	28 days	Variable*
Semi-Volatile Organic Compounds	EPA 8270	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction w/in 14 days; Analysis w/in 40 days	Variable*
Phenol bis(2-chloroethyl)ether 2-Chlorophenol 1,3-Dichlorobenzene 1,4-Dichlorobenzene Benzyl Alcohol 1,2-Dichlorobenzene 2-Methylphenol bis(2-chloroisopropyl)ether 4-Methylphenol N-nitroso-di-n-dipropylamine Hexachloroethane Nitrobenzene Isophorone 2-Nitrophenol 2,4-Dimethylphenol Benzoic Acid bis(2-chloroethoxy)methane 2,4-Dichlorophenol 1,2,4-Trichlorobenzene Naphthalene 4-Chloroaniline Hexachlorobutadiene 4-Chloro-3-methylphenol 2-Methylnaphthalene Hexachlorocyclopentadiene 2,4,6-Trichlorophenol 2,4,5-Trichlorophenol 2-Chloronaphthalene 2-Nitroaniline Dimethylphthalate Acenaphthylene 2,6-Dinitrotoluene					

TABLE 4-4
SUMMARY OF EPA METHODS FOR ANALYSES
PERFORMED ON SOIL VAPOR AND SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
3-Nitroaniline					
Acenaphthene					
2,4-Dinitrophenol					
4-Nitrophenol					
Dibenzofuran					
2,4-Dinitrotoluene					
Diethylphthalate					
4-Chlorophenyl-phenyl ether					
Fluorene					
4-Nitroaniline					
4,6-Dinitro-2-methylphenol					
N-nitrosodiphenylamine					
4-Bromophenyl-phenylether					
Hexachlorobenzene					
Pentachlorophenol					
Phenanthrene					
Anthracene					
Di-n-butylphthalate					
Fluoranthene					
Pyrene					
Butylbenzylphthalate					
3,3-Dichlorobenzidine					
Benzo(a)anthracene					
Chrysene					
bis(2-ethylhexyl)phthalate					
Di-n-octylphthalate					
Benzo(b)fluoranthene					
Benzo(k)fluoranthene					
Benzo(a)pyrene					
Indeno(1,2,3-cd)pyrene					
Dibenzo(a,h)anthracene					
Benzo(g,h,i)perylene					
Nitrate	300.0	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	28 days	Variable*
Gross Alpha and Beta	900.0	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	6 months	Variable*
pH	150.1	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	ASAP	Variable*
Total Solids	160.3	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	N/A	Variable*

TABLE 4-4
SUMMARY OF EPA METHODS FOR ANALYSES
PERFORMED ON SOIL VAPOR AND SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Dioxins	8280	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction w/in 14 days; Analysis w/in 40 days	Variable*
2,3,7,8 - TCDD					
1,2,3,7,8 - Pe CDD					
1,2,3,4,7,8 - Hx CDD					
1,2,3,6,7,8 - Hx CDD					
1,2,3,7,8,9 - Hx CDD					
1,2,3,4,6,7,8 - Hp CDD					
1,2,3,4,6,7,8,9 - OCDD					
Furans	8280	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction w/in 14 days; Analysis w/in 40 days	Variable*
2,3,7,8 - TCDF					
1,2,3,7,8 - Pe CDF					
2,3,4,7,8 - Pe CDF					
1,2,3,4,7,8 - Hx CDF					
1,2,3,6,7,8 - Hx CDF					
2,3,4,6,7,8 - Hx CDF					
1,2,3,7,8,9 - Hx CDF					
1,2,3,4,6,7,8 - Hp CDF					
1,2,3,4,7,8,9 - Hp CDF					
1,2,3,4,6,7,8,9 - OCDF					
Polychlorinated Biphenyls	8081	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction w/in 14 days; Analysis w/in 40 days	Variable*
Arochlor - 1016					
Arochlor - 1221					
Arochlor - 1232					
Arochlor - 1242					
Arochlor - 1248					
Arochlor - 1254					
Arochlor - 1260					
Polynuclear Aromatic Hydrocarbons	8310	2.5" x 6" Stainless Steel Sleeve or 8 or 16 oz Glass Jar	Cool @ 4°C	Extraction w/in 14 days; Analysis w/in 40 days	Variable*
Napthalene					
Acenaphthylene					
Acenaphthene					
Fluorene					
Phenanthrene					
Anthracene					
Fluoranthene					
Pyrene					
Chrysene					
Benzo(b)fluoranthene					
Benzo(k)fluoranthene					
Benzo(a)pyrene					
Dibenzo(a,h)anthracene					

TABLE 4-4
SUMMARY OF EPA METHODS FOR ANALYSES
PERFORMED ON SOIL VAPOR AND SOIL SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Benzo(g,h,i)perylene Indeno(1,2,3-cd)pyrene					
Volatile Organic Compounds	EPA 8260	8 or 16 oz Glass Jar	Cool @ 4°C	14 days	Variable*
Chloromethane					
Bromomethane					
Vinyl chloride					
Chloroethane					
Methylene chloride					
Acetone					
Carbon disulfide					
1,1-Dichloroethene					
1,1-Dichloroethane					
1,2-Dichloroethane					
cis-1,2-Dichloroethene					
Chloroform					
2-Butanone (MEK)					
1,1,1-Trichloroethane					
Carbon tetrachloride					
Bromodichloromethane					
1,2-Dichloropropane					
Cis-1,3-Dichloropropene					
Trichloroethene					
Dibromochloromethane					
1,1,2-Trichloroethane					
Benzene					
trans-1,3-Dichloropropene					
Bromoform					
4-Methyl-2-Pentanone					
2-Hexanone					
Tetrachloroethene					
1,1,2,2-Tetrachloroethane					
Toluene					
Chlorobenzene					
Ethylbenzene					
Styrene					
Xylene (Total)					
Vinyl acetate					
Trichlorofluoromethane (Freon 11)					
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)					
trans-1,2-Dichloroethene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
1,2-Dichlorobenzene					

Notes:

- * Method detection limits are highly matrix-dependent and are, therefore, variable. See Results tables in Section 4.0 for actual detection limits.

ASAP - As soon as possible upon delivery to laboratory.

TABLE 4-5

SOIL-VAPOR RESULTS – EVENT 1
(Concentrations in µg/L–vapor)

Soil Vapor Probe Number	Depth (ft bgs)	Date	Sample Number	1,1-DCE	CCl ₄	TCE	Freon 113	Other Analytes Detected
Event 1								
SV-1	20	1/14/94	SV-1	ND	ND	ND	ND	
SV-2	20	1/14/94	SV-2	ND	ND	ND	ND	
SV-3	20	1/14/94	SV-3	ND	ND	ND	ND	
SV-4	20	1/14/94	SV-4	ND	ND	ND	ND	3.3 1,1,1-Trichloroethane
SV-5	22	1/14/94	SV-5	ND	ND	ND	ND	
SV-5	22	1/14/94	SV-6(DUP)	ND	ND	ND	ND	
SV-7	12	1/15/94	SV-7	ND	ND	ND	ND	
SV-8	12	1/15/94	SV-8	ND	ND	ND	ND	
SV-9	19	1/15/94	SV-9	ND	ND	ND	ND	1.9 Chloroform
SV-10	20	1/15/94	SV-10	ND	ND	ND	ND	
SV-11	20	1/15/94	SV-11	ND	ND	ND	ND	
SV-12	20	1/15/94	SV-12(DUP)	ND	ND	ND	ND	
SV-13	20	1/15/94	SV-13	ND	5	ND	ND	
SV-14	20	1/15/94	SV-14	ND	1.4	ND	ND	
SV-15	20	1/15/94	SV-15	ND	15.4	5.2	ND	1.0 Tetrachloroethene
SV-16	20	1/15/94	SV-16	ND	15.1	3	ND	
SV-17	11	1/15/94	SV-17	ND	9.5	51.9	ND	
SV-17	11	1/15/94	SV-18(DUP)	ND	11.5	53.3	ND	
SV-19	19	1/15/94	SV-19	ND	5.6	ND	ND	
SV-20	19	1/15/94	SV-20	ND	3.6	ND	ND	
SV-21	10	1/16/94	SV-21	ND	ND	ND	ND	
SV-22	20	1/16/94	SV-22	ND	ND	ND	ND	
SV-23	20	1/16/94	SV-23	ND	ND	ND	ND	
SV-23	20	1/16/94	SV-24(DUP)	ND	ND	ND	ND	
SV-25	20	1/16/94	SV-25	ND	ND	ND	ND	
SV-26	14	1/16/94	SV-26	ND	ND	ND	ND	

TABLE 4-5

SOIL-VAPOR RESULTS – EVENT 1
(Concentrations in µg/L–vapor)

Soil Vapor Probe Number	Depth (ft bgs)	Date	Sample Number	1,1-DCE	CCl ₄	TCE	Freon 113	Other Analytes Detected
SV-27	16	1/16/94	SV-27	ND	ND	ND	ND	
SV-28	9	1/16/94	SV-28	ND	ND	ND	ND	
SV-29	13	1/16/94	SV-29	ND	ND	ND	ND	
SV-29	13	1/16/94	SV-30(DUP)	ND	ND	ND	ND	
SV-31	13	1/16/94	SV-31	ND	89.1	ND	ND	7.7 Chloroform
SV-32	16	1/16/94	SV-32	ND	51.6	ND	ND	10.8 Chloroform
SV-33	11	1/16/94	SV-33	ND	86.5	ND	ND	10.4 Chloroform
SV-34	8	1/16/94	SV-34	ND	ND	ND	ND	
SV-35	13	1/16/94	SV-35	ND	19.6	ND	ND	1.7 Chloroform
SV-35	13	1/16/94	SV-36(DUP)	ND	23.9	ND	ND	2.2 Chloroform
SV-37	18	1/17/94	SV-37	ND	ND	ND	ND	
SV-38	12	1/17/94	SV-38	ND	ND	ND	ND	
SV-39	19	1/17/94	SV-39	ND	ND	ND	ND	
SV-40	19	1/17/94	SV-40	ND	ND	ND	ND	
SV-41	15	1/17/94	SV-41	ND	ND	ND	ND	
SV-41	15	1/17/94	SV-42(DUP)	ND	ND	ND	ND	
SV-43	17	1/17/94	SV-43	ND	ND	ND	ND	
SV-44	11	1/17/94	SV-44	ND	ND	ND	ND	
SV-45	10	1/17/94	SV-45	ND	ND	ND	ND	
SV-46	12	1/17/94	SV-46	ND	ND	ND	ND	
SV-47	20	1/17/94	SV-47	ND	ND	ND	ND	
SV-47	20	1/17/94	SV-48(DUP)	ND	ND	ND	ND	
SV-49	20	1/18/94	SV-49	ND	ND	ND	ND	
SV-50	20	1/18/94	SV-50	ND	ND	ND	ND	
SV-52	15	1/18/94	SV-52	ND	ND	1.2	ND	
SV-53	11	1/18/94	SV-53	ND	ND	1.3	ND	
SV-54	8	1/18/94	SV-54	ND	ND	ND	ND	

TABLE 4-5

SOIL-VAPOR RESULTS – EVENT 1
(Concentrations in $\mu\text{g/L}$ -vapor)

Soil Vapor Probe Number	Depth (ft bgs)	Date	Sample Number	1,1-DCE	CCl ₄	TCE	Freon 113	Other Analytes Detected
SV-55	6	1/18/94	SV-55	ND	2.6	ND	ND	
SV-55	6	1/18/94	SV-56(DUP)	ND	2.9	ND	ND	
SV-57	17	1/18/94	SV-57	ND	ND	ND	ND	
SV-58	6	1/18/94	SV-58	ND	ND	ND	ND	

Notes:

bgs - Below ground surface.

DUP - Duplicate samples.

ND - Not detected.

SV-51 probe hit repeated refusals at depth of less than 1 foot and was not sampled.